U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-296 141

User's Manual for the Dynamic (Potomac) Estuary Model

(U.S.) Environmental Protection Agency, Annapolis, MD

Jan 79

PB 296141

U.S. ENVIRONMENTAL PROTECTION AGENCY

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

MIDDLE ATLANTIC REGION-III 6th and Walnut Streets, Philadelphia, Pennsylvania 19106

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA 903/9-79-001	2.	3. RECIPIENT'S ACCESSION NO. PB296141
4. TITLE AND SUBTITLE "User's Manual for the Dynamic (Potomac) Estuary Model"		5. REPORT DATE January 1979
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Stephen E. Roesch, Leo J. Clark and Molly M. Bray		8. PERFORMING ORGANIZATION REPORT NO. Technical Report 63
9. PERFORMING ORGANIZATION NAME AND ADDRESS Annapolis Field Office EPA, Region III Annapolis Science Center Annapolis, Maryland 21401		10. PROGRAM ELEMENT NO. 2BA644
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Same as above		13. TYPE OF REPORT AND PERIOD COVERED In-house; technical
		14. SPONSORING AGENCY CODE EPA/903/00

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Annapolis Field Office (AFO) of the Environmental Protection Agency has been actively engaged in the mathematical modeling of the Potomac Estuary since the 1960's. During the past several years, the Potomac water quality model has undergone considerable revision and expansion. This report is the first in a series of reports documenting the Potomac modeling efforts at AFO. While the model presented in this report has been adapted to the Potomac Estuary, it is by no means unique to that body of water.

This report discusses the basic principles and theories underlying the Dynamic Potomac Estuary Model. A description of the water quality interactions modeled in the Potomac are also presented. Being a User's Manual, this report also contains listings of the hydraulic and water quality models, a detailed description of each program and its logical structure, variable definitions, data deck sequences, and sample input/output.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Nitrification	D.O. Budget	Estuarine Modeling	
Photosynthesis	User's Manual	Water Quality Simulation	
Respiration		Potomac Estuary	
Algae		Mathematical Model	
Simulation			
Estuaries			

18. DISTRIBUTION STATEMENT Release Unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 326
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE PCA15 / MF-A01

EPA Form 2220-1 (9-73)

EPA 903/9-79-001

USER'S MANUAL
FOR THE
DYNAMIC (POTOMAC) ESTUARY MODEL

TECHNICAL REPORT 63

1a

EPA 903/9-79-001

USER'S MANUAL
FOR THE
DYNAMIC (POTOMAC) ESTUARY MODEL

TECHNICAL REPORT 63

January 1979

Stephen E. Roesch
Leo J. Clark
Molly M. Bray

Annapolis Field Office
Region III
U.S. Environmental Protection Agency

1b

EPA 903/9-79-001

ABSTRACT

The Annapolis Field Office (AFO) of the Environmental Protection Agency has been actively engaged in the mathematical modeling of the Potomac Estuary since the 1960's. During the past several years, the Potomac water quality model has undergone considerable revision and expansion. This report is the first in a series of reports documenting the Potomac modeling efforts at AFO. While the model presented in this report has been adapted to the Potomac Estuary, it is by no means unique to that body of water.

This report discusses the basic principles and theories underlying the Dynamic Potomac Estuary Model. A description of the water quality interactions modeled in the Potomac are also presented. Being a User's Manual, this report also contains listings of the hydraulic and water quality models, a detailed description of each program and its logical structure, variable definitions, data deck sequences, and sample input/output.

TABLE OF CONTENTS

Page

ABSTRACT i

TABLE OF CONTENTS ii

LIST OF FIGURES v

LIST OF TABLES vi

CHAPTER 1 THEORY OF THE DYNAMIC ESTUARY MODEL 1

- 1.1 Introduction 1
- 1.2 The Model Network 3
  - 1.2.1 Overview 3
  - 1.2.2 Channel Parameters 5
  - 1.2.3 Junction Parameters 6
  - 1.2.4 Network Configuration and Size 8
- 1.3 The Hydraulic Model 9
  - 1.3.1 Theory 9
  - 1.3.2 Solution Technique 14
- 1.4 The Quality Model 15
  - 1.4.1 Theory 15
  - 1.4.2 Solution Technique 36

CHAPTER 2 IMPLEMENTATION OF THE HYDRAULIC MODEL 38

- 2.1 Regression Analysis Program (REGAN) 38
  - 2.1.1 Program Description 38
  - 2.1.2 REGAN Data Deck Sequence 42
  - 2.1.3 REGAN Variable Definitions 43
- 2.2 The Hydraulic Program (DYNHYD) 45
  - 2.2.1 The MAIN Program 45
  - 2.2.2 Subroutine HYDEX 48
  - 2.2.3 Subroutine RESTRT 55
  - 2.2.4 DYNHYD Sign Conventions 57
  - 2.2.5 Input Requirements 59
  - 2.2.6 Output Options 63
  - 2.2.7 Potential Implementation Difficulties 64

TABLE OF CONTENTS
(continued)

Page

2.2.8 DYNHYD Data Deck Sequence 67
2.2.9 DYNHYD Variable Definitions 70
2.3 Computer Requirements 78
2.3.1 IBM Job Control Langauge (JCL) 78
2.3.2 UNIVAC Executive Control Langauge (ECL) 79
2.3.3 Execution Times 80

CHAPTER 3 IMPLEMENTATION OF THE WATER QUALITY MODEL - DYNQUAL 81
3.1 The MAIN Program 81
3.2 Subroutine MIXER 89
3.3 Subroutine SUMARY 92
3.4 Subroutine SWTABL 94
3.5 Subroutines SUMPLT and SWPLOT 98
3.6 Subroutine TPLOT 100
3.7 Plotting Subroutines CURVE, PPLOT, and SCALE 102
3.8 Constituent Linkages 103
3.9 Considerations For Modeling Other Systems 105
3.10 Input Requirements 109
3.11 Output Options 112
3.12 DYNQUAL Data Deck Sequence 116
3.13 DYNQUAL Variable Definitions 126
3.14 Computer Requirements 148
3.14.1 IBM Job Control Langauge (JCL) 148
3.14.2 UNIVAC Executive Control Langauge (ECL) ... 149
3.14.3 Execution Times 150

CHAPTER 4 SAMPLE INPUTS AND OUTPUTS 151
4.1 The Model Network 151
4.2 Sample REGAN Input/Output 158
4.3 Sample DYNHYD Input/Output 163

TABLE OF CONTENTS
(continued)

Page

4.4 Sample DYNQUAL Input/Output 190
    4.4.1 3 Conservative Constituents 190
    4.4.2 2 Linked Constituents 209
    4.4.3 6 Constituent D.O. Budget 229
APPENDIX 261
A.1 REGAN Listing 262
A.2 DYNHYD Listing 264
A.3 DYNQUAL Listing 275
BIBLIOGRAPHY 316

LIST OF FIGURES

Figure	Title	Page
1.1	Representation of the Model Network	4
1.2	Branching and Looping in a Network	7
1.3	Mass Transfer by Advection	17
1.4	Effect of Numerical Mixing on Model Accuracy	19
1.5	Methods of Computing C*	20
1.6	Lateral and Vertical Velocity Patterns	24
2.1	Flowchart of REGAN	40
2.2	Flowchart of the MAIN Program in DYNHYD	46
2.3	Flowchart of Subroutine HYDEX	50
2.4	Creation of the Hydraulic Extract Tape	52
2.5	HYDEX Averaging Technique	54
2.6	Flowchart of Subroutine RESTRT	56
2.7	DYNHYD Sign Conventions	58
3.1	Program and Subroutine Linkages of the DEM	82
3.2	Flowchart of the MAIN Program in DYNQUAL	83
3.3	Flowchart of the Main Quality Loop	84
3.4	Flowchart of Subroutine MIXER	90
3.5	Flowchart of Subroutine SUMARY	93
3.6	Location of High and Low Water Slack	95
3.7	Flowchart of Subroutine SWTABL	96
3.8	Flowchart of Subroutines SUMPLT and SWPLOT	99
3.9	Flowchart of Subroutine TPLOT	101
3.10	Constituent Linkages	104
3.11	Alternative Linkage: Example 1	106
3.12	Alternative Linkage: Example 2	107
3.13	Alternative Linkage: Example 3	108
4.1	The Potomac Estuary	152
4.2	Potomac Estuary Model Network: Segment 1	153
4.3	Potomac Estuary Model Network: Segment 2	154
4.4	Potomac Estuary Model Network: Segment 3	155
4.5	Potomac Estuary Model Network: Segment 4	156
4.6	Potomac Estuary Model Network: Segment 5	157

LIST OF TABLES

Table	Title	Page
1.1	Comparison of Methods for Computing C*	21
2.1	DYNHYD Execution Times	80
3.1	DYNQUAL Execution Times	150

CHAPTER 1

THEORY OF THE DYNAMIC ESTUARY MODEL

1.1 INTRODUCTION

The Dynamic Estuary Model (DEM) was originally developed during the mid 1960's by Water Resources Engineers, a consultant engineering firm located in Walnut Creek, California, under contract to the Division of Water Supply and Pollution Control, U. S. Public Health Service [1]. The principal individuals associated with the development of this model were Drs. Gerald Orlob and Robert Shubinski. Estuarine modelling was still in its infancy at that point in time, and the DEM was innovative in considering a "real time" computerized tidal solution of the hydrodynamic behavior of estuaries, including the effects of tides. Prior to the development of the DEM, the few estuary models already in existence relied on a net flow or plug flow analysis and attempted to reproduce tidal effects through the inclusion of an artificial dispersion coefficient. Since these models were non-tidal in nature, the time step for computations was normally equal to the tidal period (12.5 hrs.) or, for convenience, one day, and consequently they could not handle short term pertubations in water quality.

The DEM was initially applied to the Sacramento-San Joaquin Delta area in California [1]. Other early applications were to the Suisun, San Pablo and San Francisco Bays [2], [3]. The DEM was first brought to the attention of the Annapolis Field Office (AFO) by Mr. Kenneth Feigner in 1969. Mr. Feigner was the USPHS project officer during the early developmental and application studies in California and was the author of the basic model documentation report [4]. Staff at AFO, with the encouragement and assistance of Mr. Feigner, tested the model rigorously and performed extensive modifications to the reaction kinetics in the quality program during its multi-year application to the Potomac Estuary [5], [6], [7]. The Potomac study was primarily directed towards refining the model's ability to treat nutrient cycles (including uptake by phytoplankton) and towards incorporating algal effects within the DO budget. In addition, the DEM was also applied to the upper Chesapeake Bay during 1972-73 for the development of allowable nutrient loadings from the Susquehanna Basin and the Baltimore Metropolitan Area [8], and most recently to the Delaware Estuary [9].

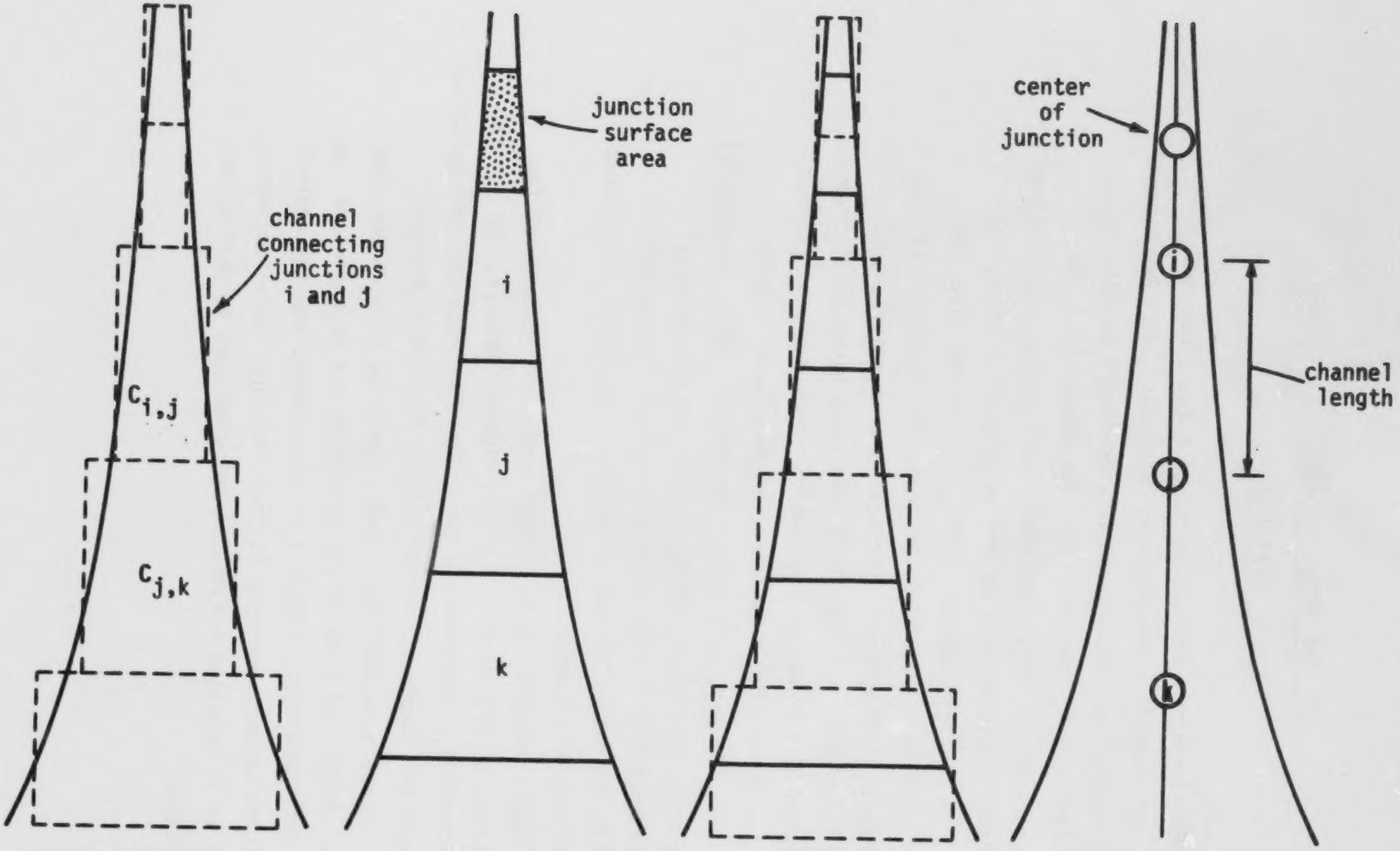
The DEM consists of two separate but interrelated components: (1) a hydraulic program, dealing with water motion, and (2) a quality program, dealing with mass transport and chemical and biological reactions. The hydraulic program predicts water movement by solving the equations of momentum and continuity, while the quality program predicts the movement, build-up, and decay of water-borne material by solving the conservation of mass equations. The numerical solution of the hydraulic and mass equations is accomplished on the same network, which represents the geometrical configuration of the estuary. The following sections will discuss in detail the network and the equations used in the hydraulic and quality models.

1.2 THE MODEL NETWORK

1.2.1 OVERVIEW

The DEM represents the prototype by using a network consisting of several interconnected "channels" and "junctions". This channel-junction (often called "link-node") network is extremely flexible in that it allows the prototype to be segmented in a manner which considers the complex flow patterns in the lateral plane as well as the effects of an irregular shoreline. A channel element (link) connects two junction elements (nodes) and serves as the transport mechanism between the junction at each end. A junction is a volumetric unit which acts as a receptacle for the fluid (and associated mass) transported through its connecting channels. A channel can connect only two junctions, but a junction can have several channels entering it. The concentration of the water quality parameters; their addition, depletion, decay, and biological/chemical transformations are defined within junctions. Parameters influencing the actual motion of water are assigned and treated in the context of channels.

The model network can be viewed as the overlapping of two closely related subnetworks: (1) the channel network, and (2) the junction network. Figures 1.1a and 1.1b illustrate the configuration of channels and junctions, respectively, for a hypothetical estuary. Since a channel must have a junction at each end, the location, shape, and size of the junctions are dependent on the channel configuration. Figure 1.1c illustrates how the channel and junction networks overlap to form the final model network. Figure 1.1d illustrates a symbolic notation used to define the model network.


channel
connecting
junctions
i and j
$C_{i,j}$
$C_{j,k}$
junction
surface
area
i
j
k
center
of
junction
i
j
k
channel
length

(a) Channel Network (b) Junction Network (c) Model Network (d) Network Representation

FIGURE 1.1 REPRESENTATION OF THE MODEL NETWORK

1.2.2 CHANNEL PARAMETERS

The parameters associated with channels are length, width, cross-sectional area, frictional resistance coefficient (Manning's "n"), velocity, and hydraulic radius or depth.

Length: The length of a channel equals the distance between the two junctions it connects. Channels must be rectangular and should be oriented so as to minimize the variation of depth over their length as well as reflect the location and position of the actual protytype channels. The channel length is generally dependent on a computational stability criteria given by

$$l_i \geq (\sqrt{gy_i} \pm u_i) \Delta t$$

where:

l_i = length of channel i

y_i = mean depth of channel i

u_i = tidal velocity in channel i

Δt = computational time step

g = acceleration of gravity

Width: There is no apparent limit on the width of a channel. However, if a channel is too wide in relation to its length, the mean velocity predicted may mask important velocity patterns occurring on a more local scale. For well defined channels, the network channel widths are equated to the average bank to bank width.

Cross-sectional area: The cross-sectional area of a channel is equal to the product of the channel width and depth. However, depth is a channel parameter that must be defined with respect to junction head or water surface elevation (since both vary similarly with time). Channels are assigned initial values of width and depth based on the initial junction heads and the initial cross-sectional areas are computed internally. As the junction heads vary, the channel cross-sectional areas are adjusted accordingly.

Roughness: Channels are assinged "typical" Manning Roughness coefficients. Since the actual value of this coefficient is virtually undefinable, it serves as a "knob" for the calibration of the model.

Velocity: An initial estimate of the mean channel velocity is required for each hydraulic run. Although any value may be assigned, the computational time required for convergence to a steady state solution will depend upon its departure from the true value.

Hydraulic radius: Previous applications of the DEM have employed channels whose widths are greater than ten times the channel depth. Consequently, the hydraulic radius is usually assumed to be equal to the mean channel depth.

1.2.3 JUNCTION PARAMETERS

The parameters associated with junctions are surface area, volume, head, and any accretion or depletion from the system.

Surface area: Except when branching or looping occurs (i.e., when more than two channels enter a junction), the surface area of a junction is equated to one-half of the sum of the surface areas of the two channels entering the junction. When branching or looping does occur, the junction surface areas can be determined by laying out a polygon network using the Thiessen Polygon method, as in Figure 1.2. Since the polygons are normally irregular, a planimeter must be relied upon to obtain surface areas.

Volume: Junction volumes are computed by multiplying the surface area of the junction by the mean depth of the channels (weighted by cross-sectional area) entering the junction.

Head: Junction heads represent the elevation of the water surface above or below an arbitrary horizontal datum. The datum is usually taken to be or referenced to Mean Sea Level.

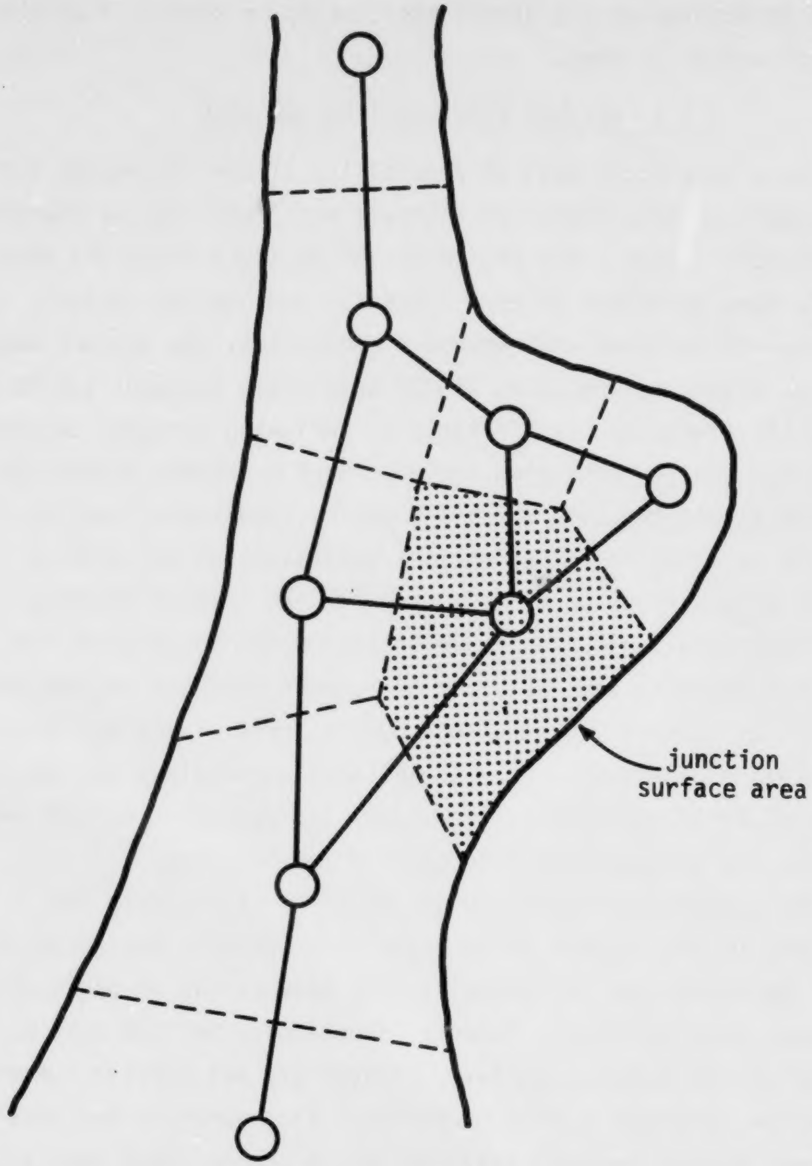

junction
surface area

FIGURE 1.2 BRANCHING AND LOOPING IN A NETWORK

Accretion/Depletion: Any accretion to or depletion from the system is handled by the direct addition to or removal from the junction volume or mass.

1.2.4 NETWORK CONFIGURATION AND SIZE

There is a great deal of flexibility allowed in laying out the network of interconnected channels and junctions to represent a particular system. The choice of the boundary locations should include considerations of both hydraulic and quality factors. To minimize difficulties with boundary conditions, the network should, ideally, extend to the ocean at the downstream boundary and to or beyond the limits of tidal effects on inflowing streams, so that the inflow can be considered steady. Such a network eliminates problems associated with dynamic boundary conditions, such as changing salinity, or other quality conditions which could be present if an inland point is chosen for the seaward boundary. Other considerations which could influence the location of the network boundaries and the scale of network elements include the location of specific points where quality predictions are required, the location of existing or planned sampling stations and the availability of data for verification, the degree of network detail desired, and the computer time desired for solution.

For computational procedures, it is necessary that the junctions of the network be numbered consecutively beginning with one. The assignment of numbers to the network can be based on any arbitrary consideration. However, junction number one must be located at the seaward boundary. A separate but similar numbering system for channels is also necessary. Each junction may have from one to five channels entering it. A channel must have a junction at one end; thus, dead-end sloughs must end with a junction. Associated with each junction number are from one to five channel numbers, and associated with each channel number are two junction numbers.

1.3 THE HYDRAULIC MODEL

1.3.1 THEORY

The primary task of the hydraulic model is to solve the equations describing the propagation of a long wave through a shallow water system, while conserving both momentum and volume. This is accomplished by (1) applying the one-dimensional equation of motion to the network channels to predict velocities and flows and (2) applying the continuity equation to the network junctions to predict fluctuations in the water surface elevation (head) and the corresponding changes in volume. The assumptions upon which this approach is based are:

1) flow is predominantly one-dimensional
2) acceleration normal to the x-axis is negligible
3) coriolis and wind forces are negligible
4) channels are rectangular with uniform cross-sectional area and a slope which can be considered negligible
5) tidal conditions (amplitude and period) at the seaward boundary are known
6) wave length is greater than or equal to twice the channel depth

The Equation of Motion - Conservation of Momentum

The equation of motion is given by

$$\frac{\partial u}{\partial t} = -u\frac{\partial u}{\partial x} - k|u|u - g\frac{\partial H}{\partial x} \qquad (1.1a)$$

where:

u = velocity along the x-axis
t = time
x = distance along the x-axis
k = frictional resistance coefficient
g = acceleration of gravity
H = head (height of the wave above an arbitrary datum)

The terms in equation (1.1a) represent the following:

$\frac{\partial u}{\partial t}$ = the time rate of change of velocity; also defined as the local inertia term

$u \frac{\partial u}{\partial x}$ = Bernoulli acceleration (the rate of momentum change by mass transfer); also defined as the convective inertia term as derived from Newton's 2nd Law

$k|u|u$ = frictional resistance (the absolute value sign insures that resistance opposes the direction of flow)

$g \frac{\partial H}{\partial x}$ = gravitational acceleration

The relationship between frictional resistance and the energy gradient is given by

$$k|u|u = g \frac{dH}{dx} \qquad (1.1b)$$

where

$\frac{dH}{dx}$ = energy gradient

For a tidally influenced estuary, few, if any, of the channels experience steady flow. However, over short time intervals, the flow can be considered as steady uniform flow. Consequently, the Manning equation, given by

$$u = \frac{1.485\ R^{2/3}\ s^{1/2}}{n} \qquad (1.1c)$$

or

$$s = \frac{n^2\ u^2}{2.208\ R^{4/3}} \qquad (1.1d)$$

where

R = hydraulic radius of the channel

s = dH/dx = energy gradient

n = Manning's n

can be used to evaluate the frictional resistance coefficient in equation (1.1a). Substitution of equation (1.1d) into equation (1.1b) defines "k" as

$$k = \frac{g\ n^2}{2.208\ R^{4/3}} \qquad (1.1e)$$

The Equation of Continuity - Conservation of Mass

The equation of continuity is given by:

$$\frac{\partial H}{\partial t} = - \frac{1}{b} \cdot \frac{\partial Q}{\partial x} \qquad (1.2)$$

where:

H = head

b = mean channel width

Q = flow

The terms in equation (1.2) represent the following:

$\frac{\partial H}{\partial t}$ = time rate of change of water surface elevation

$\frac{1}{b} \cdot \frac{\partial Q}{\partial x}$ = change in storage along the channel length per unit width

As presented, equations (1.1a) and (1.2) apply to channels. To minimize computational requirements, equation (1.2) is applied to junctions so that:

$$\frac{\partial H}{\partial t} = - \frac{\partial Q}{A^*} \qquad (1.3)$$

where:

A* = surface area of the junction

For use in the model, both equations (1.1a) and (1.3) must be changed to their finite difference forms:

$$\frac{U_{i,t} - U_{i,t-1}}{\Delta t} = -U_{i,t-1}\left(\frac{\Delta U_i}{X_i}\right) - K|U_{i,t-1}|U_{i,t-1} - g\left(\frac{\Delta H_i}{X_i}\right) \tag{1.4}$$

and

$$\frac{H_{j,t} - H_{j,t-1}}{\Delta t} = \frac{-\Sigma Q}{A^*_j} \tag{1.5}$$

where:

$U_{i,t}$ = velocity in channel i at time t

$U_{i,t-1}$ = velocity in channel i at time t-1

Δt = computational time step

X_i = length of channel i

$\Delta U_i/X_i$ = velocity gradient in channel i

$\Delta H_i/X_i$ = water surface gradient in channel i

$H_{j,t}$ = water surface elevation in junction j at time t

$H_{j,t-1}$ = water surface elevation in junction j at time t-1

A^*_j = surface area of junction j

ΣQ = algebraic summation of flows into (accretions) and out of (depletions) a junction

K = frictional resistance coefficient ($gn^2/2.208R^{4/3}$)

n = Manning's "n"

R = hydraulic radius of a channel

g = acceleration of gravity

The velocity gradient term ($\Delta U_i/X_i$) presents some computational problems because the computed velocity for a channel is assumed to be constant throughout that channel, hence there is no predicted velocity gradient within a given channel. If branching does not occur, a velocity gradient can be computed as the difference of the velocities in the channels connected to the junctions at each end of channel i. If branching does occur, this approach cannot be used, since there would be several channels connected to the upstream and downstream junctions. Equation (1.6) can be used to solve this problem.

$$\frac{\partial H}{\partial t} = -\frac{1}{b}\ \frac{\partial Q}{\partial x} = -\frac{1}{b}\ \frac{\partial (uA)}{\partial x} \qquad (1.6)$$

$$b\,\frac{\partial H}{\partial t} = -\ \frac{u\partial A}{\partial x} - A\ \frac{\partial u}{\partial x}$$

$$\therefore\ \frac{\partial u}{\partial x} = -\ \frac{b}{A}\ \frac{\partial H}{\partial t} - \frac{u}{A}\ \frac{\partial A}{\partial x}$$

In finite difference form, this becomes

$$\frac{\Delta u_i}{x_i} = -\ \frac{b_i}{A_i}\ \frac{\Delta H_i}{\Delta t} - \frac{u_i}{A_i}\ \frac{\Delta A_i}{x_i} \qquad (1.7)$$

The expression $\Delta H_i/\Delta t$ is computed as the average of the changes in water surface elevation of the junctions at each end of channel i during the time step (Δt). Similarly, the expression $\Delta A_i/X_i$ is obtained by computing the cross-sectional area at each end of channel i based on the water surface elevation of the junctions at each end.

At this point, there is one equation for each channel and each junction. Given the network configuration and geometry, initial values for channel velocities and junction heads, and specified boundary conditions, (e.g. seaward tidal variations) equations (1.4) and (1.7) can be solved using a modified Runge-Kutta procedure. The solution will converge for a given set of boundary conditions to a dynamic equilibrium having velocities, flows, and heads repeated at intervals equal to the specified tidal period.

1.3.2 SOLUTION TECHNIQUE

The solution of the equations of motion and continuity as described proceeds as follows:

1) The mean velocity for each channel is predicted for the middle of the next time interval (i.e., for time $t + \Delta t/2$) using the channel velocities and cross-sectional areas and the junction heads at the beginning of the time interval.

2) The flow in each channel at the middle of the next time interval is computed using the velocity obtained in step (1) and the cross-sectional area at the beginning of the interval.

3) The head at each junction at the middle of the next time interval is computed using the flows derived in step (2).

4) The cross-sectional area of each channel at the middle of the next time interval is computed using the heads computed in step (3).

5) The mean velocity for each channel is predicted for the full time step ($t + \Delta t$) using the velocities, cross-sectional areas, and junction heads computed for the middle of the time step ($t + \Delta t/2$) in steps (1), (3), and (4).

6) The flow in each channel after a full time step is computed using the velocity for the full time step (computed in step 5) and the cross-sectional area computed for the middle of the time step in step (4).

7) The head at each junction after a full time step is computed using the full step flow computed in step (6).

8) The cross-sectional area of each channel after a full time step is computed using the full step heads from step (7).

9) Repeat steps (1) through (8) for the specified number of time intervals.

1.4 THE QUALITY MODEL

1.4.1 THEORY

The task of the quality model is to solve the equations describing the movement, decay, and transformation(s) of a material by performing a mass balance at each junction for each time step. The quality model is referenced to the same network used in the hydraulic model, and uses the hydraulic solution (heads, flows, and velocities for each time step) as input. Since the time step for the quality program is usually much larger than the time step for the hydraulic program, the hydraulic parameters occurring within a quality time step are averaged. These averaged values cover a full tidal cycle and are stored for use by the quality program. Consequently, the quality time step must be a whole multiple of the hydraulic time step and evenly divisible into the tidal period.

Six constituents, either conservative or non-conservative, can be handled simultaneously by the version of the DEM presented in this report. The concentration of a constituent at any point is affected by mass transfers (advection, dispersion, diffusion), decay, biological/chemical transformations, and the import or export of mass.

Advection

Advection is a hydraulic mechanism which moves a constituent in the direction of flow at the same velocity at which the water moves. The basic transport equation for advection is:

$$T_a = u \cdot c \tag{1.8}$$

where

T_a = advective transport of a given mass through a unit area in a unit time (mass/area/time)

u = velocity

c = concentration of the constituent in the water

If an infinitesimal volume of water is considered, the one-dimensional equation describing concentration is:

$$\frac{\partial c}{\partial t} = u \frac{\partial c}{\partial x} \quad (1.9)$$

where

$\partial c/\partial x$ = concentration gradient along the x-axis
$\partial c/\partial t$ = time rate of change of concentration

If both sides of equation (1.9) are multiplied by volume $(A \cdot \Delta x)$, then the following mass balance equation is obtained:

$$\frac{\partial M}{\partial t} = u \frac{\partial c}{\partial x} \cdot (A \cdot \Delta x) \quad (1.10)$$

where

A = cross-sectional area
x = length along the x-axis
$\partial M/\partial t$ = time rate of change of mass

This describes the instantaneous advection of mass at a cross-section. A general finite difference form of equation (1.10) is:

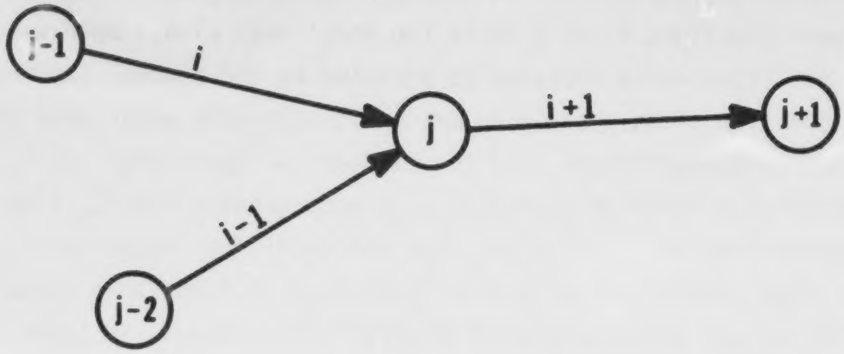
$$\frac{\Delta M_j}{\Delta t} = \Sigma (u \cdot A \cdot c)_{in} - \Sigma (u \cdot A \cdot c)_{out} \quad (1.11)$$

where

j = the junction being considered
u = velocity of water in a channel
A = cross-sectional area of a channel
c = concentration within a junction

Figure (1.3) illustrates how equation (1.11) computes the change of mass within a junction due to advection.

$$\frac{\Delta M_j}{\Delta t} = \sum(u\cdot A\cdot c)_{in} - \sum(u\cdot A\cdot c)_{out}$$



$$\frac{\Delta M_j}{\Delta t} = u_i\ A_i\ c_{j-1} + u_{i-1}\ A_{i-1}\ c_{j-2} - u_{i+1}\ A_{i+1}\ c_j$$

where $\longrightarrow$ indicates the direction of flow

u_{i-1}, u_i, u_{i+1} = velocity in channels i-1, i, and i+1

A_{i-1}, A_i, A_{i+1} = cross-sectional area of channels i-1, i, and i+1

c_{j-2}, c_{j-1}, c_j = concentration in junctions j-2, j-1, and j

FIGURE 1.3 MASS TRANSFER BY ADVECTION

Numerical Mixing

When solved by finite difference methods, the advection equation is subject to a problem known as "numerical mixing". During every quality time step, mass is transferred between adjacent junctions. As shown in Figure 1.4 , a problem arises because the model assumes that the mass transferred from junction A to junction B is completely mixed within junction B (i.e., that the mass from junction A is transferred to the center of junction B). In reality, however, water velocities are highly variable and will, at times, advance only to the boundary between junctions A and B while the model must always move mass in unit steps whose distance is dictated by the channel lengths and junction sizes. The greatest difficulty will arise when there is a high concentration gradient between two junctions. If C_A (the concentration in junction A) is much greater than C_B (the concentration in junction B), then the error introduced by advancing constituent mass from junction A to junction B ahead of the actual water mass will be numerically large. In order to insure that the discrepancy between model and river concentrations will not be large and will not accumulate because of numerical mixing problems, certain adjustments must be made.

The solution is to choose a concentration (C^*) in the advected water which is between the "actual" values of C_A and C_B. Feigner [4] examined several techniques for determining C^*. His results are summarized in Figure 1.5 and Table 1.1.

Turbulent (eddy) Diffusion

In a calm body of water, molecular diffusion will slowly operate to bring constituents from regions of high concentrations to regions of low concentrations. In turbulent bodies of water, however, this relatively slow process can be neglected, and only the effects of turbulent diffusion need to be considered. Turbulent diffusion, the stirring or mixing of the water by eddy currents due to tidal action or some other energy field (such as density

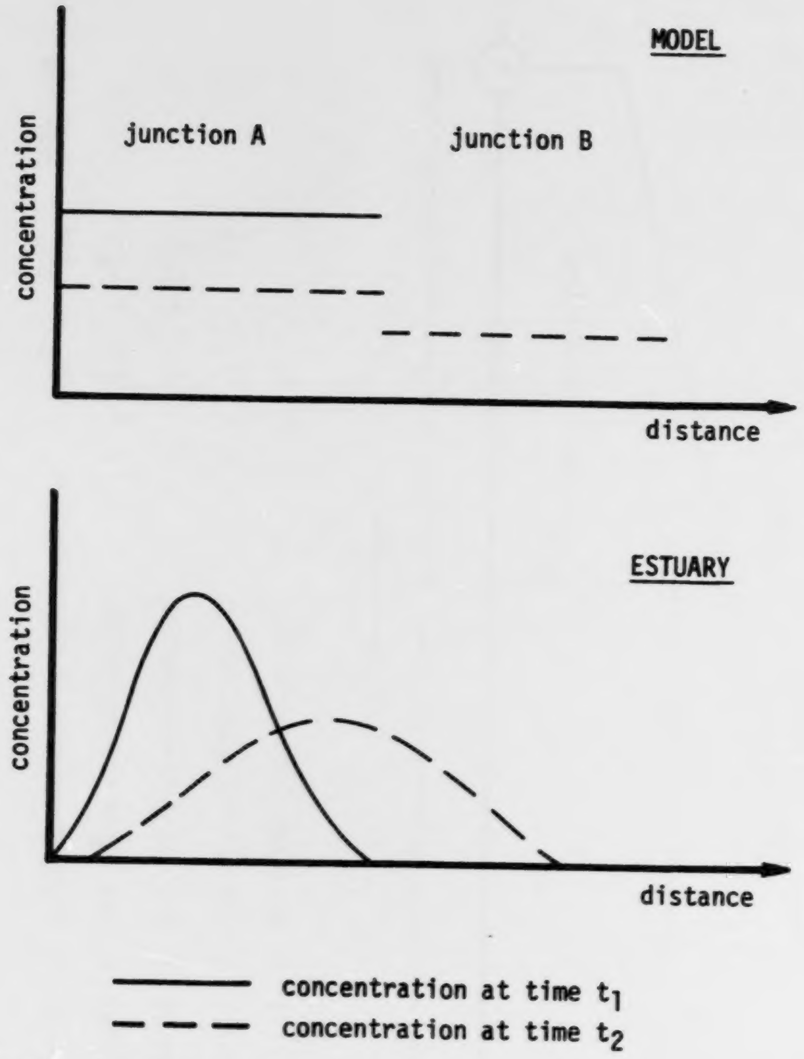
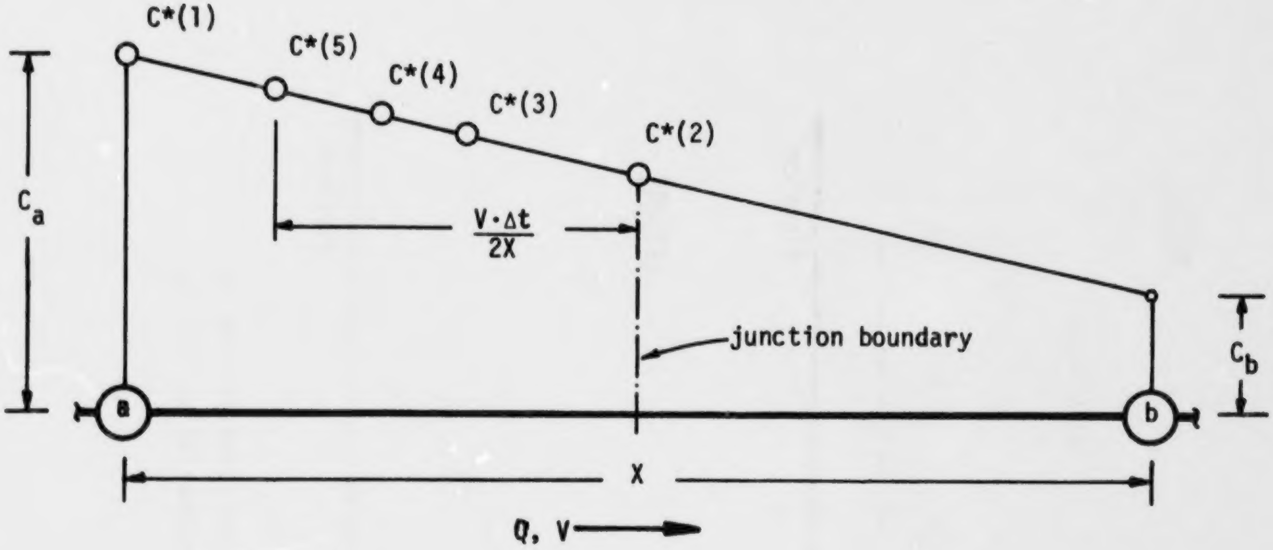


FIGURE 1.4 EFFECT OF NUMERICAL MIXING ON MODEL ACCURACY


C*(1)
C*(5)
C*(4)
C*(3)
C*(2)
C_a
$\frac{V\cdot\Delta t}{2X}$
junction boundary
C_b
a
b
X
Q, V

$C^*(1)$ = Upstream Concentration = C_a

$C^*(2)$ = 1/2 Point Concentration = $(C_a + C_b)/2$

$C^*(3)$ = 1/3 Point Concentration = $(2C_a + C_b)/3$

$C^*(4)$ = 1/4 Point Concentration = $(3C_a + C_b)/4$

$C^*(5)$ = 2-Way Proportional Concentration = $(C_a + C_b)/2 + \frac{V\cdot\Delta t}{2X}(C_a - C_b)$

FIGURE 1.5 METHODS OF COMPUTING C*

Method	Definition of C* (See Figure 1.5)	Numerical Mixing	Accuracy	Stability
Upstream	$C^* = C_a$	High	Poor	Excellent
1/2 Point	$C^* = (C_a + C_b)/2$	Low	Good	Very Poor
1/3 Point	$C^* = (C_a + C_b)/3$			
1/4 Point	$C^* = (C_a + C_b)/4$	Moderate	Good	Acceptable
2 - Way Proportional	$C^* = (C_a + C_b)/2 + \frac{V\Delta t}{2x}(C_a - C_b)$	Low	Good	Poor

TABLE 1.1 COMPARISON OF METHODS FOR COMPUTING C*

gradients), is essentially a complex form of advection, which must at present be treated as a separate process, since the velocities and directions of the eddy currents are not yet predictable. The transport equation for turbulent diffusion is:

$$T_d = K_d \cdot \frac{\partial c}{\partial x} \qquad (1.12)$$

where

T_d = transport by turbulent diffusion through a unit area in a unit time

K_d = empirically determined coefficient describing the rate of transfer (length^2/time)

$\partial c/\partial x$ = concentration gradient over the space scale

Applying this equation to a control volume and shrinking it to infinitesimal size will yield a partial differential equation describing the time rate of change of a constituent's concentration due to turbulent or eddy diffusion:

$$\frac{\partial c}{\partial t} = K_d \cdot \frac{\partial^2 c}{\partial x^2} \qquad (1.13)$$

Multiplying this equation by a volumetric term $(A \cdot \partial x)$ yields a differential equation which relates turbulent diffusion at cross-section A on a mass flux basis:

$$\frac{\partial M}{\partial t} = K_d \cdot \frac{\partial^2 c}{\partial x^2} \cdot A \cdot \partial x \qquad (1.14)$$

Again, converting the mass transfer equation to finite difference form and expressing distance in terms of a channel element's length results in:

$$\frac{\Delta M_j}{\Delta t} = K_d A_{i+1} \frac{\Delta C_{i+1}}{\Delta x_{i+1}} - K_d A_i \frac{\Delta C_i}{\Delta x_i} \qquad (1.15)$$

where

j = junction under consideration

i, $i+1$ = downstream and upstream channels, respectively

ΔC_i, ΔC_{i+1} = concentration differenced along the downstream and upstream channels, respectively

This difference equation describes the net dispersion of mass into or out of junction j during the interval Δt.

The DEM does not utilize K_d directly but, rather, computes this rate based upon a simplification of the energy dissipation relationship and a spatial approximation of the eddy size [4]. The actual equation employed by the model is as follows:

$$K_d = C_4 | u | R \qquad (1.16)$$

where

C_4 = dimensionless diffusion constant which can be varied spatially

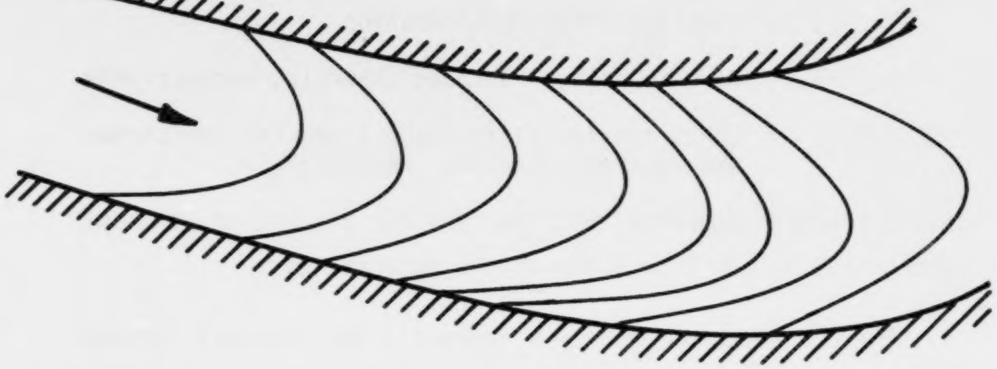
u = mean channel velocity

R = hydraulic radius of the channel

Longitudinal Dispersion

The velocity of a river varies both laterally and vertically, as shown in Figure 1.6. These variations result in longitudinal dispersion, the mechanism by which mass in the center of the river moves forward faster than the mass at the sides or bottom. Since the velocity used in equation (1.11) is assumed to be the mean velocity in the channel (i.e. the model is one-dimensional in form), this phenomenon cannot be directly accounted for by the model. However, the phenomenon of numerical mixing accidentally

Lateral variation of velocity



Vertical variation of velocity

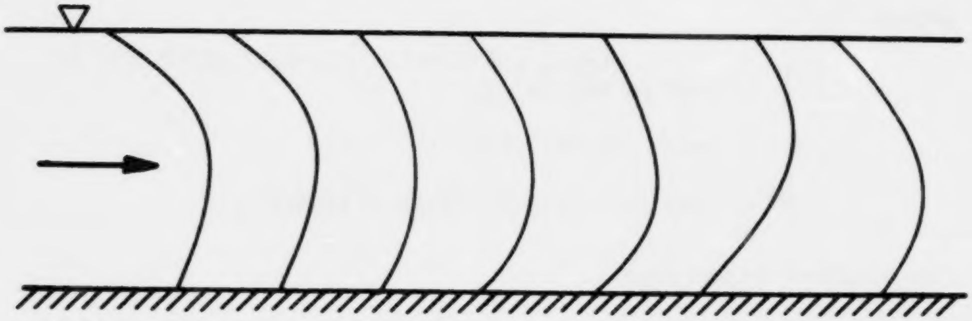


FIGURE 1.6 LATERAL AND VERTICAL VELOCITY PATTERNS

produces a somewhat similar effect, although it is only partially controllable. In fact, there are two procedures which can help encompass the effects of longitudinal dispersion.

1) further adjustment of C* (the concentration used in equation (1.11) for advection)
2) adjustment of the turbulent (eddy) diffusion coefficient (C_4)

Decay

The quality model is capable of describing the fate of both conservative (e.g. salinity) and non-conservative (e.g. BOD or DO) constituents. For non-conservative constituents, the mechanism of decay must be considered.

Zero-Order Decay

For zero-order decay, the quantity of constituent decayed is a function of the rate constant for the reaction being considered. Mathematically, a zero-order reaction is given by

$$\frac{dc}{dt} = -K \tag{1.17}$$

where

dc/dt = rate of change of c with respect to t
c = concentration
t = time
K = rate constant (mass/volume/time)

The negative sign indicates that the process is one of decay rather than growth. Equation (1.17) is easily integrated to yield:

$$C_t = C_o - K \ (t - t_o) \tag{1.18}$$

where

C_t = concentration at time t
C_o = concentration at time t_o

This expression can be converted to a finite difference form for a time step of Δt.

$$C_o - C_t = \Delta C_j = K \cdot \Delta t \qquad (1.19)$$

where

ΔC_j = change (decrease) in concentration in junction j during a time interval of Δt

The corresponding mass equation is obtained by multiplying both sides of equation (1.19) by volume.

$$V_j \cdot \Delta C_j = \Delta M_j = K \cdot V_j \cdot \Delta t \qquad (1.20)$$

where

V_j = volume of junction j

ΔM_j = change (decrease) in mass in junction j during a time interval of Δt

Example 1 - Algal Respiration and Photosynthesis

If algal respiration is assumed to be a zero-order reaction, i.e. if the rate at which oxygen is consumed by algae is independent of their concentration, then the rate at which oxygen is removed from the system is given by:

$$\frac{\Delta M_R}{\Delta t} = K_R \cdot V \cdot C_{algae}$$

where

ΔM_R = mass of dissolved oxygen consumed by algae during a time interval of Δt

K_R = rate at which algae consume oxygen (mass of O_2/mass of algae/time)

C_{algae} = concentration of algae (mass/volume)

V = volume

Algal photosynthesis is not a process of decay. However, if it is assumed to be a zero-order reaction, i.e. if the rate at which algae produce oxygen is independent of their concentration, then the rate at which oxygen is added to the system is given by:

$$\frac{\Delta M_p}{\Delta t} = K_p \cdot V \cdot C_{algae}$$

where

ΔM_p = mass of dissolved oxygen produced by algae during a time interval Δt

K_p = rate at which algae produce oxygen (mass of O_2/mass of algae/time)

C_{algae} = concentration of algae

V = volume

The mass of oxygen present in the system at time t is given by:

$$M_t = M_{t-1} + \Delta M_p - \Delta M_R$$

where

M_t = mass of oxygen present at time t

M_{t-1} = mass of oxygen present at time t-1

Example 2 - Sediment Oxygen Demand

If the rate at which oxygen is consumed by bottom sediments is considered constant, i.e. independent of the amount of bottom sediment present, then the change in dissolved oxygen mass due to sediment oxygen demands is given by:

$$\frac{\Delta M_{DO}}{\Delta t} = K_{SOD} \cdot A$$

where

ΔM_{DO} = mass of oxygen consumed by bottom sediments during a time interval Δt

K_{SOD} = rate at which bottom sediments consume oxygen (mass O_2/area/time)

A = surface area of bottom

First-Order Decay

For first-order decay, the quantity of constituent decayed is a function of (1) the amount of the constituent present and (2) the rate constant for the reaction being considered. Mathematically, a first-order reaction is given by:

$$\frac{dc}{dt} = -K \cdot C \qquad (1.21)$$

where

dc/dt = rate of change of c with respect to t
K = rate constant (1/time)
C = concentration
t = time

Again, the negative sign indicates that the process is one of decay rather than growth. Equation (1.21) can be easily integrated to yield:

$$C_t = C_o \; e^{-K\,(t-t_o)} \qquad (1.22)$$

where

C_t = concentration at time t
C_o = concentration at time t_o

This expression can be converted to a finite difference form for a time interval of Δt

$$C_{j,t-1} - C_{j,t} = \Delta C_j = C_{j,t-1} \; (1-e^{-K\Delta t}) \cdot \Delta t \qquad (1.23)$$

where

ΔC_j = change (decrease) in concentration in junction j during a time interval of Δt
$C_{j,t-1}$; $C_{j,t}$ = concentration in junction j at time t-1 and t, respectively
Δt = computational time step

The corresponding mass equation is obtained by multiplying both sides of equation (1.23) by volume

$$V_j \cdot \Delta C_j = \Delta M_j = V_j \cdot C_{j,t-1} (1-e^{-K\Delta t}) \cdot \Delta t$$

where

V_j = volume of junction j

ΔM_j = change in mass in junction j during a time interval of Δt

Example 1 - Biochemical Oxygen Demand (BOD)

The rate at which organic wastes are biochemically oxidized or stabilized is directly proportional to the amount of unstabilized material present. The change in the amount of unstabilized material present (BOD) is given by:

$$\frac{\Delta M_{BOD}}{\Delta t} = V \cdot C_{BOD,\ t-1} \cdot (1-e^{-K_\beta \Delta t})$$

where

ΔM_{BOD} = amount of BOD stabilized during a time interval of Δt

V = volume

Δt = time interval

$C_{BOD,t-1}$ = concentration of BOD at time t-1

K_β = rate at which organic material is stabilized

The amount of BOD present at time t is given by:

$$M_{BOD,t} = M_{BOD,\ t-1} - \Delta M_{BOD}$$

where

$M_{BOD,t-1}$, $M_{BOD,t}$ = mass of BOD present at time t-1 and t, respectively

Example 2 - Reaeration

The oxygen in water is naturally replenished through the process of reaeration (mass transfer at the surface). This process is defined by:

$$\frac{dD}{dt} = -K_d \cdot D$$

where

D = dissolved oxygen deficit, i.e. the saturation concentration minus the actual concentration

K_d = reaeration rate (1/time)

Reaeration is a process in which the dissolved oxygen deficit is reduced (or, conversely, in which the dissolved oxygen concentration is increased). The change in mass of the DO deficit due to reaeration is given by:

$$\frac{\Delta M}{\Delta t} = V \cdot D_{t-1} \cdot (1-e^{-K_d \Delta t})$$

where

ΔM = decrease in the mass of dissolved oxygen deficit (or, the increase in DO mass during a time interval of Δt)

V = volume

D_{t-1} = DO deficit at time t-1

Second-Order Decay

For second-order decay, the quantity of constituent decayed is a function of (1) the amount of constituent present and (2) the rate constant of the reaction. Mathematically, a second-order reaction is given by:

$$\frac{dc}{dt} = -Kc^2 \qquad (1.24)$$

where

dc/dt = rate of change of c with respect to t

K = rate constant (volume/mass/time)

c = concentration

Again, the negative sign indicates that the process is one of decay. Equation (1.24) can be integrated to yield

$$C_t = \frac{1}{k(t-t_o) + \frac{1}{C_o}} = \frac{1}{C_o k(t-t_o) + 1} \qquad (1.25)$$

This can be converted to a finite difference form for a time interval of Δt:

$$\Delta C_j = C_{j,t-1} - C_{j,t} = C_{j,t-1}\left[1 - \frac{1}{(C_{j,t} \cdot k\Delta t)+1}\right] \Delta t \qquad (1.26)$$

where

ΔC_j = change (decrease) in concentration in junction j during the time interval Δt

$C_{j,t-1}$, $C_{j,t}$ = concentration in junction j a times t-1 and t, respectively

Δt = computational time step

The corresponding mass equation is obtained by multiplying equation (1.26) by the junction volume:

$$\Delta M_j = V_j \cdot \Delta C_j \qquad (1.27)$$

where

ΔM_j = change in mass in junction j during a time interval of Δt

V_j = volume of junction j

Example 1 - Sedimentation/Deposition

Many substances are removed from the water system through the process of sedimentation (i.e. settling). Quite often, the rate at which material is removed by this process can be described by first or second order reactions. If the process is a second order one, then the change in mass of a constituent is given by

$$\frac{\Delta M_s}{\Delta t} = V \cdot C_{t-1} \left[1 - \frac{1}{(C_{t-1} \cdot k_s \cdot \Delta t) + 1} \right]$$

where

ΔM_s = amount of mass removed by settling during the time interval Δt

Δt = time step

V = volume

C_{t-1} = concentration at time t-1

k_s = rate at which the material settles

If sedimentation were the only process affecting the material, then the mass present at time t would be given by

$$M_t = M_{t-1} - \Delta M_s$$

where

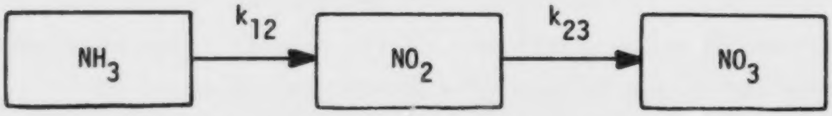
M_{t-1}, M_t = mass of constituent present at times t-1 and t, respectively

Biological / Chemical Transformations

Materials in the aquatic ecosystem often undergo some type of transformation(s). In many cases, these consecutive reactions can be described by the kinetics discussed earlier.

Example 1 - Nitrification

Nitrification is the process by which ammonia (NH_3) is converted to nitrite (NO2) and nitrate (NO_3), as shown in the figure below.



Assuming first order kinetics, the change in mass of each constituent during a time interval of Δt is given by

$$\frac{\Delta M_{NH3}}{\Delta t} = V \cdot C_{NH3,t-1} \cdot (1 - e^{-k_{12}\Delta t})$$

$$\frac{\Delta M_{NO2}}{\Delta t} = \frac{\Delta M_{NH3}}{\Delta t} - V \cdot C_{NO2,t-1} \cdot (1 - e^{-k_{23}\Delta t})$$

$$\frac{\Delta M_{NO3}}{\Delta t} = V \cdot C_{NO2,t-1} \cdot (1 - e^{-k_{23}\Delta t})$$

where

ΔM_{NH3} = the amount of NH_3 converted to NO_2 during Δt

ΔM_{NO2} = the change in mass of NO_2 during Δt

ΔM_{NO3} = the amount of NO_2 converted to NO_3 during Δt

$C_{NH3,t-1}$ = the concentration of NH_3 at time t-1

$C_{NO2,t-1}$ = the concentration of NO_2 at time t-1

$C_{NO3,t-1}$ = the concentration of NO_3 at time t-1

k_{12} = the rate at which NH_3 is converted to NO_2

k_{23} = the rate at which NO_2 is converted to NO_3

The mass of each constituent at time t is given by

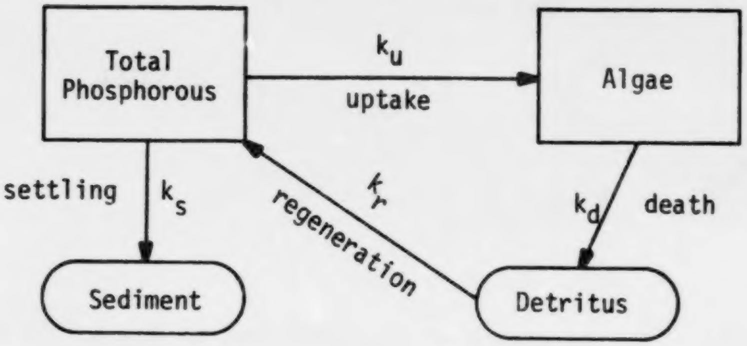
$$M_{NH3,t} = M_{NH3,t-1} - \Delta M_{NH3}$$

$$M_{NO2,t} = M_{NO2,t-1} + \Delta M_{NH3} - \Delta M_{NO3}$$

$$M_{NO3,t} = M_{NO3,t-1} + \Delta M_{NO3}$$

Example 2 - The Phosphorus Cycle

A simplified representation of the phosphorus cycle is shown in the figure below.


Total Phosphorous
k_u
uptake
Algae
settling
k_s
k_r
regeneration
k_d
death
Sediment
Detritus

Assume that (1) the uptake of phosphorous by algae, the death of algae, and the regeneration of phosphorous from detritus are all first order reactions

(2) the settling of phosphorous is a second order reaction

The change in mass of phosphorous and algae during Δt is given by

$$\frac{\Delta M_p}{\Delta t} = \text{regeneration} - \text{uptake} - \text{settling}$$

$$= M_{pd}\cdot(1 - e^{-k_r \Delta t}) - C_{p,t-1}\cdot V\cdot(1 - e^{-k_u \Delta t})$$

$$- V\cdot C_{p,t-1}\left(1 - \frac{1}{(C_{p,t-1}\cdot k_d\cdot \Delta t)+1}\right)$$

$$\frac{\Delta M_a}{\Delta t} = \text{growth} - \text{death}$$

$$= C_{p,t-1}\cdot V\cdot(1 - e^{-k_u \Delta t}) - C_{A,t-1}\cdot V\cdot(1 - e^{-k_s \Delta t})$$

where ΔM_A = change in algae mass during Δt

ΔM_p = change in phosphorous mass during Δt

M_{pd} = mass of phosphorous present in the detritus

$C_{p,t-1}$ = concentration of phosphorous at time t-1

V = volume

$C_{A,t-1}$ = concentration of algae at time t-1

The mass of phosphorous and algae present at time t is given by

$$M_{p,t} = M_{p,t-1} + \Delta M_p = M_{p,t-1} + \Delta M_r - \Delta M_u - \Delta M_s$$

$$M_{A,t} = M_{A,t-1} + \Delta M_A = M_{A,t-1} + \Delta M_u - \Delta M_d$$

where

$M_{p,t-1}$, $M_{p,t}$ = mass of phosphorous present at times t-1 and t, respectively

$M_{A,t-1}$, $M_{A,t}$ = mass of algae present at times t-1 and t, respectively

ΔM_r = mass of phosphorous regenerated from the detritus during Δt

ΔM_u = mass of phosphorous taken up by algae for growth during Δt

ΔM_s = mass of phosphorous removed from the system through settling during Δt

ΔM_d = mass of algae decayed into detritus during Δt

Import / Export

Another process which will affect the mass of a constituent in a junction is the import (e.g. tributary inflow or waste discharge) and/or export (e.g. water supply withdrawal or industrial use) of water from the system. The mass of constituent added (or subtracted) at a junction during each time interval Δt is given by

$$\frac{\Delta M_j}{\Delta t} = \Sigma Q_{in} \cdot C_{in} - \Sigma Q_{out} \cdot C_j \qquad (1.28)$$

where

ΔM_j = the change in mass in junction j during Δt

Q_{in} = flow into junction j

C_{in} = concentration of the constituent in the inflow

Q_{out} = withdrawal from junction j

C_j = concentration of constituent in junction j

1.4.2 SOLUTION TECHNIQUE

Conservation of mass is maintained within the network junctions by combining the equations describing the following processes:

- advection
- diffusion
- decay
- biological/chemical transformations
- import/export

The solution of the quality program is a relatively straightforward and sequential process involving an explicit finite difference technique. The algorithm is as follows.

1) Initial junction volumes and concentrations are specified in order to determine the total mass of each constituent initially present in each junction.

2) Waste load data (e.g.imports and exports) is specified for each junction.

3) Hydraulic parameters are read. Values for channel velocities and flows and junction heads for each time step are read from the "hydraulic extract tape" created by the hydraulic program.

4) Advection - mass is transferred between adjacent junctions in the direction of flow. The amount of mass transferred is determined using a representative concentration (C*).

5) Diffusion - mass is transferred between adjacent junctions from the junction with the higher concentration to the junction with the lower concentration. The amount of mass transferred is proportional to the concentration gradient.

Steps 4 and 5 proceed from one channel to another, until every channel and junction has been examined.

6) Any non-conservative constituents are decayed. If D.O. is a constituent, reaeration occurs here.

7) The wastewater loads and/or withdrawals specified in Step 2 are applied to the appropriate junctions.

8) Hydraulic parameters (flows, velocities, and heads) for the next time step are read from the "hydraulic extract tape".

9) A new concentration for each junction is obtained by dividing the total mass of constituent by the new junction volume.

10) Steps 4 through 10 are repeated for every time step.

CHAPTER 2

IMPLEMENTATION OF THE HYDRAULIC MODEL

2.1 REGRESSION ANALYSIS PROGRAM (REGAN)

2.1.1 PROGRAM DESCRIPTION

When applying the hydraulic model, a tidal input characteristic of the conditions under consideration must be imposed at the seaward boundary of the model. For simulation of an historic condition, the tidal wave chosen should be representative of the tidal conditions which existed at that time. Since it is expensive to simulate a transient condition having significantly varying flows or tidal characteristics, the tide and flow for any historic simulations should be relatively steady. The tidal wave at the seaward boundary is described by

$$\begin{aligned} Y = {} & A_1 + A_2\sin(\omega t) + A_3\sin(2\omega t) + A_4\sin(3\omega t) \\ & + A_5\cos(\omega t) + A_6\cos(2\omega t) + A_7\cos(3\omega t) \end{aligned} \tag{2.1}$$

where

Y = head (elevation above or below a horizontal datum)

A_i = regression coefficients

ω = tidal period (hours)

The coefficients A_1 through A_7 are obtained through the regression analysis program (REGAN) which requires tidal heights at equally spaced intervals throughout a tidal period as input. Normally, 30 minute intervals will suffice. This input can be obtained from prototype tidal stage recorders (if available) at the boundary. In the absence of such data, it may be necessary to use the predictions presented in the Tide Tables published by the U.S. Coast and Geodetic Survey.

Figure 2.1 is a simplified flowchart depicting the sequence of steps for REGAN. A brief description of the program logic is as follows:

STEP 1 - READ AND PRINT CONTROL AND INPUT DATA

Alphanumeric data is read which describes the run, the number of observations (*NDATA*), the number of coefficients *(NCOEFF)*, the maximum number of iterations allowed in the computational loop *(MAXIT)*, the maximum residual allowed for termination of calculations *(MAXRES)*, the tidal period *(PERIOD)*, time shift parameter *(TSHIFT)*, phase angle shift parameter *(PSHIFT)*, the time of the i^{th} observation *(T(I))*, and the value of the i^{th} observation *(Y(I))*. Tables displaying the inputs are printed.

STEP 2 - INITIALIZATION

Variables and arrays used in the calculations of the regression coefficients *(A(I)*, J = 1,*NCOEFF)* are initialized.

STEP 3 - SET UP NORMAL EQUATIONS

The coefficients of the normal equations *(SXX(K,J)* and *SXY(J)*, where J = 1,*NCOEFF* and K = 1,*NCOEFF)* are established.

STEP 4 - SOLVE NORMAL EQUATIONS

The equations established in STEP 3 are used to determine estimates of the regression coefficients. If the maximum number of iterations allowed have been completed, the program procedes to STEP 5. If the number of iterations is less than the maximum number allowed and the maximum residual is greater than the desired maximum residual *(MAXRES)*,

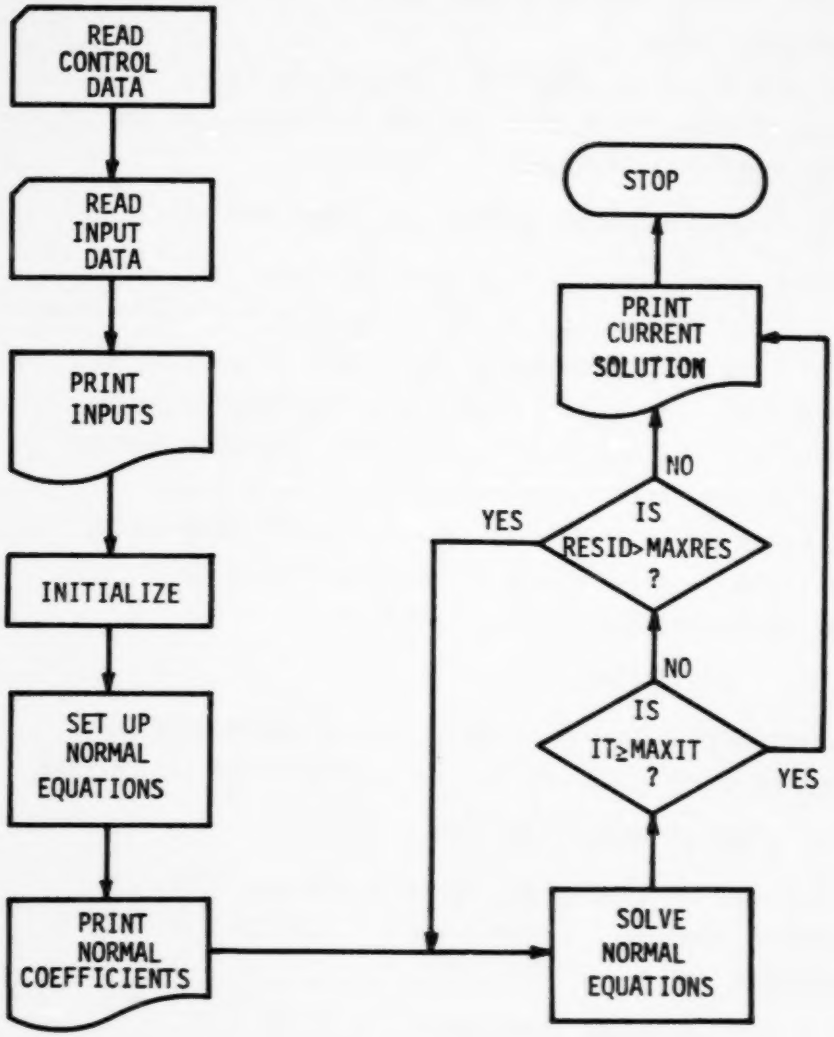

READ
CONTROL
DATA
READ
INPUT
DATA
PRINT
INPUTS
INITIALIZE
SET UP
NORMAL
EQUATIONS
PRINT
NORMAL
COEFFICIENTS
SOLVE
NORMAL
EQUATIONS
IS
IT≥MAXIT
?
YES
NO
IS
RESID>MAXRES
?
YES
NO
PRINT
CURRENT
SOLUTION
STOP

FIGURE 2.1 FLOWCHART OF REGAN

then another iteration is performed to obtain better estimates of the regression coefficients. If the number of iterations is less than the maximum number allowed and the maximum residual is less than or equal to the specified maximum residual, the program proceeds to STEP 5.

STEP 5 - PRINT OBSERVED AND PREDICTED DATA

Tables are printed containing (1) the computed regression coefficients, (2) the observed and predicted data values, and (3) the residual values.

2.1.2 REGAN DATA DECK SEQUENCE

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
1	ALPHA(I)	1 - 80	20A4	Read 2 cards
2	NDATA	1 - 10	I10	
	NCOEFF	11 - 20	I10	
	MAXIT	21 - 30	I10	
	MAXRES	31 - 40	F10.0	
	PERIOD	41 - 50	F10.0	
	TSHIFT	51 - 60	F10.0	
	PSHIFT	61 - 70	F10.0	
3	T(1)	1 - 8	F8.0	This card is repeated until all NDATA values of T and Y are read. Each card contains 8 values of T and Y.
	Y(1)	9 - 16	F8.0	
	T(2)	17 - 24	F8.0	
	Y(2)	25 - 82	F8.0	
	.	.	.	
	.	.	.	
	.	.	.	
	T(NDATA)		F8.0	
	Y(NDATA)		F8.0	

2.1.3 REGAN VARIABLE DEFINITIONS

The following section contains definitions for the major variables in REGAN. Variables are listed in alphabetical order. Variables in italics are read from the input data deck.

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
A(J)		Coefficients obtained by the program which describe the tidal input at a specified junctions. (J = 1, NCOEFF)	R	
ALPHA		Alphanumeric data which describes the run.	R	
MAXIT		Maximum number of iterations desired in the run.	I	
MAXRES		Maximum value of the residual allowed. Will not be exceeded unless the number of iterations reaches MAXIT before the residual reaches MAXRES (a value of .0001 is typically used).	R	
NCOEFF		Number of coefficients in the trigonometric equation.	I	
NDATA		Number of input data points over a tidal cycle.	I	
PERIOD		The period of the tide.	R	hrs.
PSHIFT		Variable which allows the phase angle in the trigonometric relationship to be shifted (usually set equal to zero).	R	
T(I)		Time of the I^{th} specified data point on the input tide (I = 1,NDATA)	R	hrs.
TSHIFT		Variable which allows the time scale for the inputs to be shifted (usually set equal to zero).	R	
Y(I)		Elevation of the I^{th} specified data point on the input data (referenced to model datum).	R	ft.

2.2 THE HYDRAULIC PROGRAM (DYNHYD)

2.2.1 THE "MAIN" PROGRAM

Figure 2.2 is a simplified flowchart depicting the sequence of steps for the Main program of DYNHYD. A brief description of the program logic is as follows:

STEP 1 - READ CONTROL DATA

Alphanumeric data is read which identifies the network size *(NC* and *NJ)*, the length of the run *(NCYC)*, and output control parameters (see Section 2.2.6).

STEP 2 - READ JUNCTION DATA

A separate card is read for each junction. Each card contains the junction number, initial head at that junction, surface area of the junction, the inflow (or outflow) to the junction, and the numbers of the channels entering the junction. After all junction cards are read, a table summarizing the data is printed.

STEP 3 - READ CHANNEL DATA

A separate card is read for each channel. Each card contains the channel number, physical characteristics (length, width, cross-sectional area, hydraulic radius, and Manning's n), initial velocity, and the numbers of the two junctions at the ends of the channel. After all channel cards are read, a table summarizing the data is printed.

STEP 4 - INPUT TIDAL CONDITIONS AT SEAWARD BOUNDARY

The period of the tide (hours) and the coefficients obtained by REGAN (see Section 2.1) to define the tidal wave at the seaward boundary are read and printed. The version

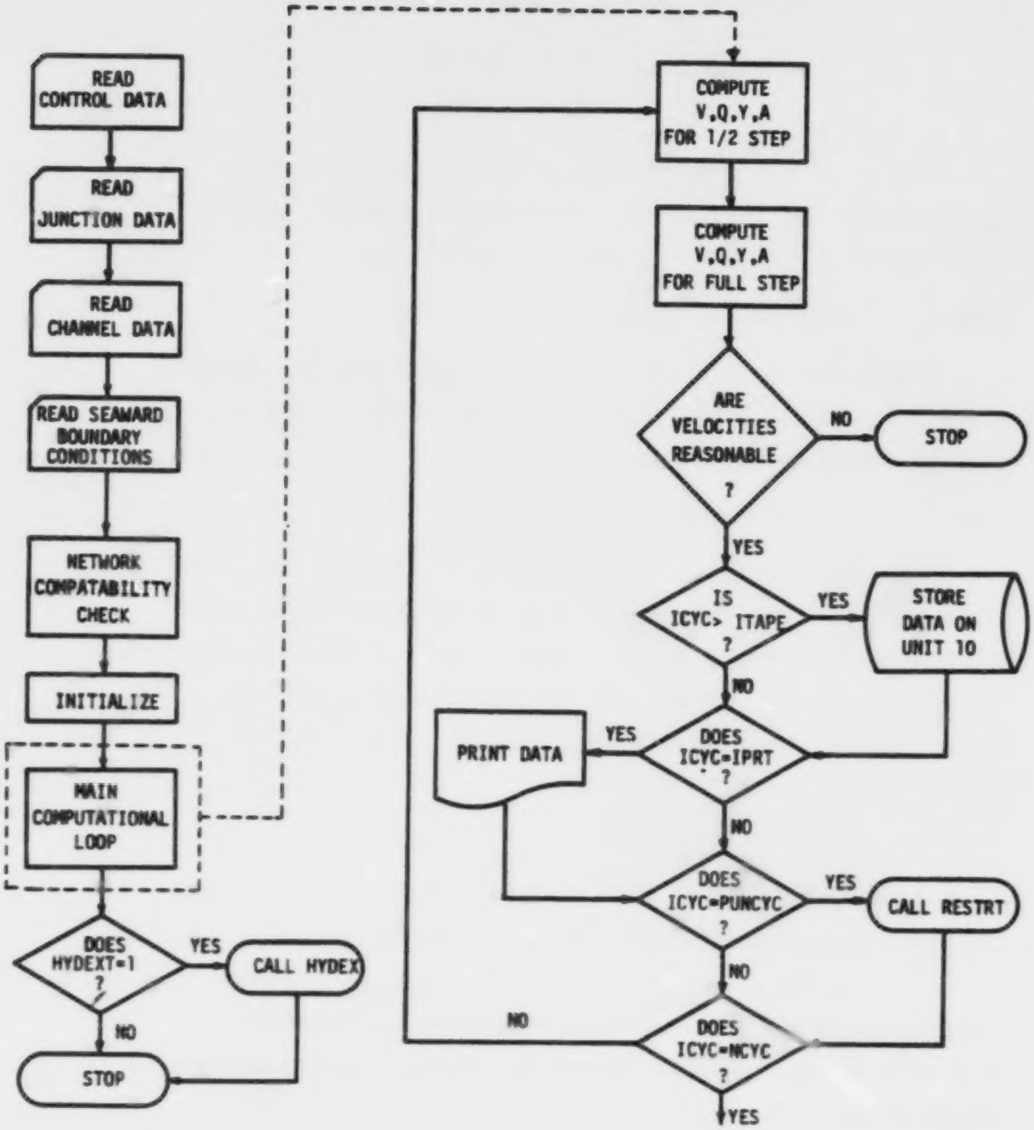

READ CONTROL DATA
READ JUNCTION DATA
READ CHANNEL DATA
READ SEAWARD BOUNDARY CONDITIONS
NETWORK COMPATABILITY CHECK
INITIALIZE
MAIN COMPUTATIONAL LOOP
DOES HYDEXT=1 ?
YES
CALL HYDEX
NO
STOP
COMPUTE V,Q,Y,A FOR 1/2 STEP
COMPUTE V,Q,Y,A FOR FULL STEP
ARE VELOCITIES REASONABLE ?
NO
STOP
YES
IS ICYC> ITAPE ?
YES
STORE DATA ON UNIT 10
NO
DOES ICYC=IPRT ?
YES
PRINT DATA
NO
DOES ICYC=PUNCYC ?
YES
CALL RESTRT
NO
DOES ICYC=NCYC ?
NO
YES

FIGURE 2.2 FLOWCHART OF THE MAIN PROGRAM IN DYNHYD

of the hydraulic model contained herein allows only one seaward boundary. However, the program can easily be altered to accomodate several seaward boundary inputs.

STEP 5 - CHECK COMPATABILITY OF CHANNELS AND JUNCTIONS

A check is made on the compatability of the junction and channel numbering systems. If a junction is listed as being connected to a given channel, then that channel should also be listed as being connected to the junction. Execution will terminate if any discrepencies are found.

The control parameters and the channel and junction data are stored on Unit 10 (temporary magnetic tape or disk).

STEP 6 - INITIALIZATION

Initializes various computation parameters, converts starting time and tidal period from hours to seconds, and computes friction coefficient *(AK(N))* for each channel. Checks the junction numbers at each end of a channel and insures that the junction number associated with *NJUNC(N,1)* is smaller than the junction jumber associated with *NJUNC(N,2)*. This is necessary for the sign convention used to specify the direction of flow in a channel (see Section 2.2.4).

STEP 7 - MAIN COMPUTATIONAL LOOP

If the run is a continuation of a previous run, it is desirable to record the initial conditions (junction heads and channel velocities and flows) on Unit 10. This will be done if variable *IWRTE* = 0. Normally, however, these parameters need not be stored.

The program follows the algorithm described in section Section 1.3.2. Channel velocities, flows, and cross-sectional areas and junction heads are computed for one-half of a time step. These half-step values are then used to compute the full-step values.

The channel velocities are then checked for reasonableness. If a channel velocity exceeds 20 fps, computational instability is indicated and execution is terminated.

The current cycle number *(ICYC)*, junction heads *(Y(J))*, and channel velocities *(V(N))* and flows *(Q(N))* are stored on Unit 10 if the current cycle is greater than or equal to a specified value *(ITAPE)*.

A check is made to determine whether the predictions for the current cycle are to be printed, If so, then the next print cycle is set and printout is obtained for the specified junctions. Printout will always be obtained for the last cycle of the run.

A check is made to determine whether or not Subroutine RESTRT should be called (see Section 2.2.3 for a description of RESTRT). If the current cycle is a specified restart cycle *(PUNCYC)*, then Subroutine RESTRT is called.

STEP 8 - EXIT MAIN LOOP AND CHECK FOR HYDEX

Following the completion of the specified number of computation cycles, a check is made to determine whether or not Subroutine HYDEX is to be called (see Section 2.2.2 for a description of HYDEX). If *HYDEXT* = 1, Subroutine HYDEX is called.

2.2.2 SUBROUTINE HYDEX

As discussed earlier, the quality program time step is usually much longer than a hydraulic time step. The time interval used by the quality program must be a whole multiple *(NODYN)* of the hydraulic time step and evenly divisible into the tidal period. For example, given a tidal period of 12.5 hours, a hydraulic time step of 1.5 minutes, and a quality time step of 30 minutes, *NODYN* would be specified as 20. HYDEX is a subroutine which summarizes (averages) the output stored on Unit 10 for *NODYN* hydraulic cycles and permanently stores these values on Unit 4 (magnetic tape or disk) for use as input to the quality model.

In addition to summarizing the inter - tidal values of channel velocities and flows and junction heads, HYDEX also determines (1) the minimum and maximum flows, velocities, and cross-sectional areas of channels, (2) minimum and maximum heads of junctions, and the cycles at which they occur, (3) net flow in a channel, (4) average cross-sectional area of a channel, (5) average head of a junction, and (6) range of heads for a junction over an entire tidal cycle.

Figure 2.3 is a simplified flow chart depicting the sequence of steps for Subroutine HYDEX. A brief description of the program logic is as follows:

STEP 1 - READ CONTROL DATA

Reads alphanumeric data identifying the run *(ALPHA(I),*I = 41,80*)* and the number of hydraulic time steps per quality time step *(NODYN)*.

STEP 2 - READ AND ALIGN INPUT TAPE

The hydraulic summary provided by HYDEX is for a complete tidal cycle. Therefore, it is necessary to determine the hydraulic cycles at which the last full tidal cycle begins *(NSTART)* and ends *(NSTOP)*. This is necessary because, in some cases, the data stored on Unit 10 may exceed a full tidal cycle. Because the hydraulic solution converges to a dynamic steady state solution, the predictions for the last full tidal cycle are used because they are the most representative of the steady state condition. Unit 10 is rewound. The system data stored by the MAIN program is read. Unit 10 is then aligned over cycle *NSTART* and the summary procedure begins.

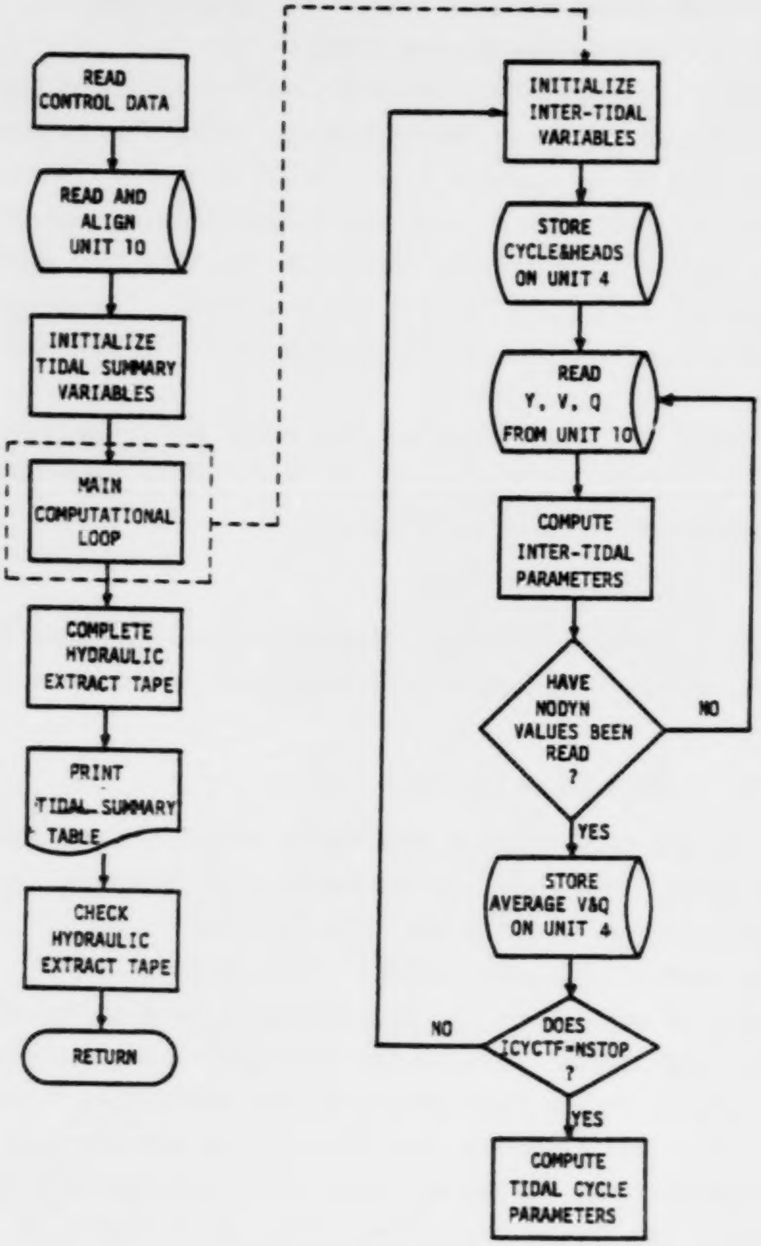

READ CONTROL DATA
READ AND ALIGN UNIT 10
INITIALIZE TIDAL SUMMARY VARIABLES
MAIN COMPUTATIONAL LOOP
COMPLETE HYDRAULIC EXTRACT TAPE
PRINT TIDAL SUMMARY TABLE
CHECK HYDRAULIC EXTRACT TAPE
RETURN
INITIALIZE INTER-TIDAL VARIABLES
STORE CYCLE&HEADS ON UNIT 4
READ Y, V, Q FROM UNIT 10
COMPUTE INTER-TIDAL PARAMETERS
HAVE NODYN VALUES BEEN READ ?
NO
YES
STORE AVERAGE V&Q ON UNIT 4
DOES ICYCTF=NSTOP ?
NO
YES
COMPUTE TIDAL CYCLE PARAMETERS

FIGURE 2.3 FLOWCHART OF SUBROUTINE HYDEX

STEP 3 - INITIALIZE SUMMARY VARIABLES

HYDEX computes two types of summary variables. The first group consists of parameters summarized over an entire tidal cycle. These parameters are: net flow in a channel *(QNET(N))*; minimum and maximum velocity *(VMIN(N), VMAX(N))* and flow *(QMIN(N), QMAX(N))* in a channel; minimum, maximum, and average cross-sectional areas of channels *(ARMIN(N), ARMAX(N), ARAVG(N))*, and minimum, maximum, and average junction heads *(YMIN(J), YMAX(J), YAVG(J))*. The second group consists of parameters summarized for discrete intervals within the tidal cycle (i.e. inter-tidal cycle variables). The parameters are the average flow *(QEXT(N))* and velocity *(VEXT(N))* in a channel. These are the values which are obtained by averaging the flows and velocities for *NODYN* hydraulic time steps and are then stored permanently on the "hydraulic extract tape" (Unit 4) for use by the quality program.

The tidal cycle summary variables are initialized only once. However, the inter-tidal cycle variables must be initialized before each inter-tidal summary (i.e. after *NODYN* cycles of data are read and summarized, the values of the inter-tidal summary variables must be re-set). At the start of every inter-tidal summary, the current hydraulic cycle number and the junction heads are stored on Unit 4.

STEP 4 - COMPUTE SUMMARY PARAMETERS

Inter-tidal cycle parameters: The junction heads, channel flows, and channel velocities for *NODYN* hydraulic cycles are read from the record on Unit 10, created by the MAIN program. The heads, flows, and velocities are accumulated, averaged, and stored on Unit 4 (the "hydraulic extract tape"). This process is depicted in Figure 2.4.

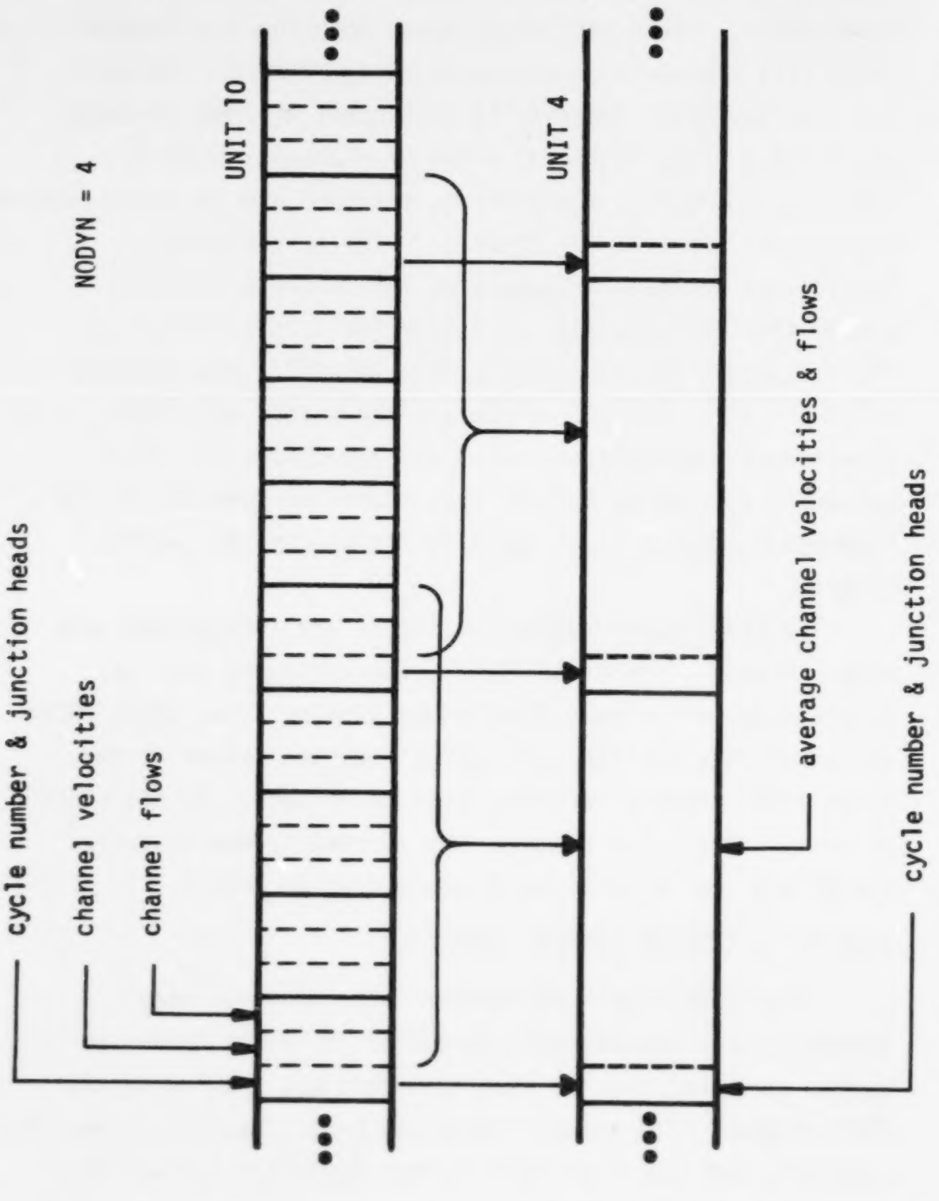

cycle number & junction heads
channel velocities
channel flows
NODYN = 4
UNIT 10
UNIT 4
average channel velocities & flows
cycle number & junction heads

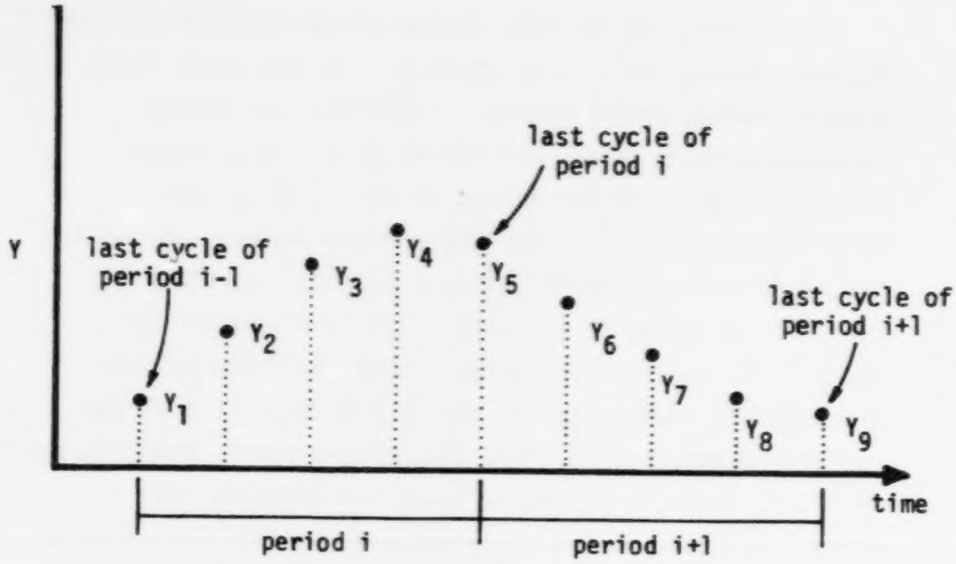
FIGURE 2.4 CREATION OF THE HYDRAULIC EXTRACT TAPE

To compute the average channel flows (*QEXT(N))* and the average channel velocities *(VEXT(N))* for the inter-tidal summary period (*NODYN* cycles), HYDEX does not simply accumulate *NODYN* values and divide their sum by *NODYN*. Instead, a more refined method of averaging is used. Data from the last cycle of the previous summary period and data from the next *NODYN* cycles are used, i.e. NODYN + 1 cycles of data are accumulated. However, a weight of one-half is assigned to the data from the last cycle of the previous summary period and to the last cycle of the current summary period. The accumulated sum is then divided by *NODYN*. This technique is identical to using the trapezoidal rule to determine the area under a curve over a certain interval *(NODYN)* and then dividing the area by the interval length *(NODYN)* to obtain the average height along that interval. This technique is shown in Figure 2.5.

Tidal cycle parameters: The net flow in a channel over a tidal cycle is computed by averaging the accumulated channel flows. The averaging technique is similar to the method used in STEP 4. The channel cross-sectional area for each cycle are computed and then accumulated over the entire tidal cycle, and averaged. Junction heads are accumulated over the entire tidal cycle and averaged. Checks are made to determine the minimum and maximum values of the following parameters over the entire tidal cycle: channel velocities, channel cross-sectional areas, and junction heads.

STEP 5 - COMPLETE WRITING HYDRAULIC EXTRACT TAPE

After the inter-tidal cycle variables for an entire tidal cycle have been computed and stored on Unit 4, various channel and junction parameters are stored at the end of the hydraulic extract tape.


Y
last cycle of period i-1
Y_1
Y_2
Y_3
Y_4
last cycle of period i
Y_5
Y_6
Y_7
Y_8
last cycle of period i+1
Y_9
time
period i
period i+1

NODYN = 4

$$\text{Average during period } i = \frac{\tfrac{1}{2}Y_1 + Y_2 + Y_3 + Y_4 + \tfrac{1}{2}Y_5}{4}$$

$$\text{Average during period } i{+}1 = \frac{\tfrac{1}{2}Y_5 + Y_6 + Y_7 + Y_8 + \tfrac{1}{2}Y_9}{4}$$

$$\text{Average during period } N = \left(\tfrac{1}{2}(Y_\alpha - Y_\beta) + \sum_{i=\alpha+1}^{\beta-1} Y_i\right) \div \text{NODYN}$$

$$\alpha = \text{NSTART} + \text{NODYN}\cdot(N-1)$$

$$\beta = \alpha + \text{NODYN}$$

NSTART = cycle at which summaries begin

FIGURE 2.5 HYDEX AVERAGING TECHNIQUE

STEP 6 - OUTPUT TIDAL CYCLE SUMMARY TABLES

Tables containing both the tidal and inter-tidal summary variables are printed for the model channels and junctions.

STEP 7 - CHECK HYDRAULIC EXTRACT TAPE

Unit 4, the hydraulic extract tape, is rewound and read completely. The hydraulic cycles which were stored on Unit 4 are printed along with the heads at several junctions and the "extract" flows (i.e. the flows computed by HYDEX) in several channels. This provides a check on the data actually stored on Unit 4.

STEP 8 - RETURN TO THE MAIN PROGRAM

2.2.3 SUBROUTINE RESTRT

Subroutine RESTRT has two functions. First, it stores pertinent restart parameters on Unit 4 for use as a restart device in the event of premature termination of execution. Second, it outputs a punched card deck (after the last computational cycle is completed) containing the channel and junction parameters in a format which can be used as an input deck. This type of output is desirable if the run is to be extended. Figure 2.6 is a simplified flowchart describing the sequence of steps for RESTRT.

If the current hydraulic cycle is the last computational cycle, the final channel and junction parameters are punched onto a card deck. A printed summary of this data is also given.

Prior to the final computational cycle, the current channel and junction parameters are stored on Unit 4. The next restart cycle is specified by incrementing the current cycle by *INTPUN* (i.e. *PUNCYC* = *PUNCYC* + *INTPUN*). Unit 4 is rewound so that if computations proceed to the next restart cycle, the data already stored will be updated.

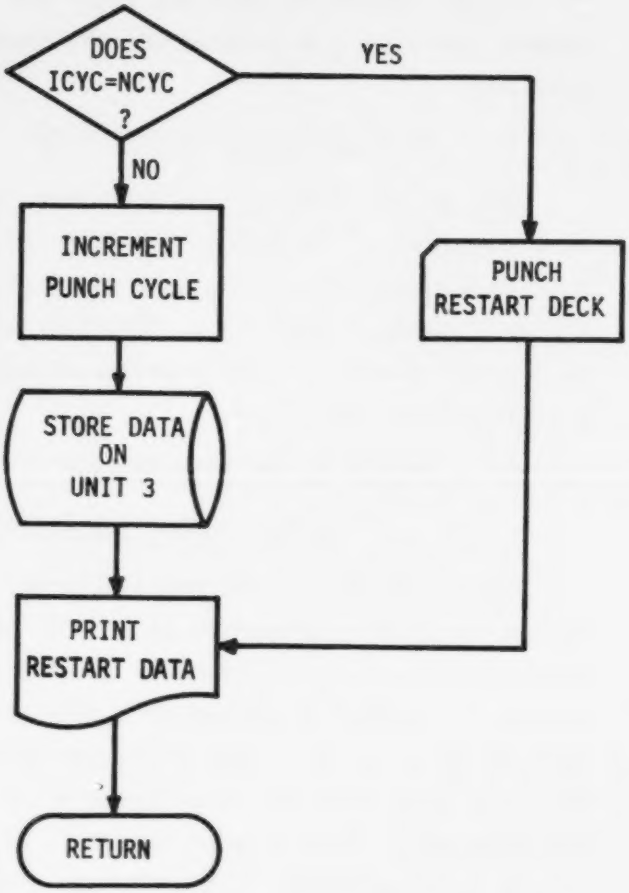

DOES ICYC=NCYC ?
YES
NO
INCREMENT PUNCH CYCLE
PUNCH RESTART DECK
STORE DATA ON UNIT 3
PRINT RESTART DATA
RETURN

FIGURE 2.6 FLOWCHART OF SUBROUTINE RESTRT

Note that Unit 4 serves a dual purpose in the hydraulic program. If premature termination of execution occurred, subroutine HYDEX (which also uses Unit 4) would not be called and Unit 4 would contain the data needed to restart the run from the last restart cycle. If execution is not terminated prematurely, then the hydraulic conditions existing at the end of the run would be punched onto a card deck before HYDEX was called. The rewind command in HYDEX will ready Unit 4 for storing the hydraulic parameters used by the quality program.

2.2.4 DYNHYD SIGN CONVENTIONS

There are two different sign conventions used in the hydraulic model. The convention used in reference to junctions describes flow into or out of a junction. Specifically, negative values are assigned to any flow entering a junction, while positive values indicate flow leaving a junction (see Figure 2.7). This convention applies regardless of the source of the flow. Inflow from a waste discharge and from and adjacent junction are treated in the same manner.

For channels, signs indicate the direction of flow and velocity. When the flow is from the end of the channel having the lower of the two junction numbers (*NJUNC(N,1)*) toward the end with the higher *(NJUNC(N,2))*, it is assigned a positive value. Flow is considered negative when travelling from the end of the channel with the higher of the two junction numbers toward the end with the lower (see Figure 2.7).

The channel flows are outputted using the junction sign convention so that the user can see if water flows into or out of a particular junction. The channel flow and velocity signs are converted to junction sign convention strictly for convenience in interpreting the output. To interpret

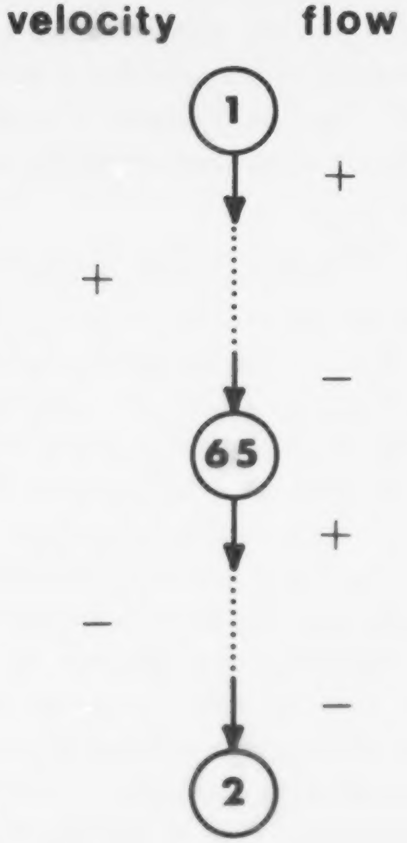

velocity
flow
1
+
+
−
65
+
−
−
2

FIGURE 2.7 DYNHYD SIGN CONVENTIONS

the direction of channel flow, it is necessary to know the configuration of channels and junctions, i.e. which junction is at each end of a channel. This information can be found in the Channel Data table at the beginning of the DYNHYD output.

2.2.5 INPUT REQUIREMENTS

The input requirements for the hydraulic program can vary tremendously, depending on the uniqueness of the conditions to be simulated. In any case, the data requirements for the initial application of the model to a system are considerable.

PHYSICAL PARAMETERS OF THE PROTOTYPE

As discussed earlier, the channels and junctions of the model network must be described by certain physical parameters.

Channel Parameters:	Length, width, depth, surface area, roughness, cross-sectional area
Junction Parameters:	head, volume

For all runs subsequent to the initial run, the input data requirements are greatly reduced. Many of the physical parameters such as channel lengths and widths and the surface area of each junction remain constant during execution and, therefore, do not vary between runs. Similarly the network layout and numbering systems generally remain constant. Only if physical changes in the prototype (real or proposed) are to be modeled is it necessary to change the model network.

MANNING'S ROUGHNESS COEFFICIENT

As mentioned earlier, the roughness coefficient (Manning's n) acts as a "tuning knob" for the hydraulic model. Unfortunately, there is no exact method for defining the value of n, and one must rely on literature values, sound engineering judgement, and personal experience to estimate its value.

The value of n is highly variable and depends on the following factors: surface roughness, vegetation, channel irregularities in cross-section or shape, obstructions, silting and scouring, stage, and discharge [10]. Before attempting to estimate n, Chow [10] recommends that one attempts to (1) understand the factors which affect the value of n so as to narrow the range of guesswork, (2) consult the literature for representative values, and (3) examine and become acquainted with channels whose roughness coefficients are known.

There are some methods which have been suggested for the computation of n. Cowan [11] has proposed an empirical procedure which includes several of the factors that influence n. Two other methods, based on the theoretical velocity distribution in a rough channel, have also been proposed. The first method uses the observed vertical velocity distribution and is described by Boyer [12] and Langbien [13]. The second uses a "roughness function" to determine n and is described by Einstein and Barbarossa [14]. Davidson, et.al. [15] outline a numerical technique which determines the best - distributed values of n based on observed tidal heights.

When calibrating the hydraulic model, changing the value of n in one channel will affect the upstream channels in one way and the downstream channels in another. Increasing n causes more energy to be dissipated in that channel. As a result, the height of the tidal wave will decrease and the time of travel through the channel will increase. Lowering n decreases the resistance to flow, i.e. less energy is dissipated. This results in a higher tidal wave and a shorter time of travel. In general, the value of n will increase as one moves up the estuary since channels become more constricted.

INITIAL CONDITIONS

The most demanding of these inputs are the channel cross-sectional areas and the junction heads. The specified junction heads establish the water surface elevation throughout the network and correspond to those areas. The heads throughout the system are referenced to a common, horizontal datum, such as mean sea level. Channel depths can usually be obtained with sufficient accuracy from the soundings printed on navigation charts published by the Coast and Geodetic Survey. Unfortunately, however, these soundings are normally representative of a mean low water condition at the point of the sounding and are not referenced to a common datum. It is therefore necessary to establish the relationship selected for the model. Such relationships may be available for certain points in the system, such as at tidal stage recorders or at other points where tidal predictions are made. River bed profiles may also be available from which such relationships could be determined. Once the relationships between the junction heads and channel cross-sectional areas have been properly established for a given system, they should never have to be reestablished because the model program maintains the proper relationship at all times during execution. It is usually most expeditious to specify a constant value for each of the junction heads (assumes a horizontal water surface) in preparing the data for the first time and then adjust the channel depths (and cross-sectional areas) accordingly. While it might be desirable, in order to save computation time, to sepcify the initial heads at each junction in such a manner that the water surface profile is more representative of one which actually occurs in the prototype, such an effort is probably not warranted. Unless extensive tide data is available to establish the water surface elevation at many points in the system for a given instant in time, a great deal of interpolation between points will be required. It is doubtful whether the execution time saved by such a procedure warrants the additional effort involved.

A similar argument holds for the specification of the initial velocity in each channel. Normally, data in sufficient quantity will not be available to establish a detailed velocity pattern for the entire system at a given instant in time. Therefore, a constant initial velocity (such as zero) is assumed throughout the system. Thus, for the initial run on a new system, the total mass of water might initially be assumed to be at rest with a horizontal water surface. As the solution progresses it will converge to the appropriate dynamic steady state condition wherein the head at each junction and the velocity and flow in each channel are repeated with a frequency equal to the period of the specified tide. Normally, four complete tidal cycles will be sufficicnt to reach a steady state condition. If relatively accurate initial conditions are specified, fewer tidal cycles are needed.

TIDAL CONDITIONS

The tidal conditions at the seaward boundary are described by a set of regression coefficients. These coefficients are derived for any tidal condition by program REGAN (see Section 2.1).

ACCRETIONS / DEPLETIONS

The accretions or depletions at each junction in the system must by specified for each run. Although not programmed for the version of the hydraulic model contained in this report, it would be relatively simple to input accretions/ depletions which vary with time.

CONTROL DATA

Control data is usually unique for each run and may need to be respecified.

2.2.6 OUTPUT OPTIONS

The hydraulic program can provide three types of output: printed output, output stored on magnetic tape or disk, or punched output in the form of a restart deck.

Printed output: Printed output can occur in the MAIN program, Subroutine HYDEX, and Subroutine RESTRT.

In the MAIN program, printed output is controlled by four parameters: *IPRINT*, *INTRVL*, *NOPRT*, and *JPRT(I)*, where I = 1,*NOPRT*. Printout begins at cycle *IPRINT* and will occur every *INTRVL* cycles thereafter for *NOPRT* specified junctions. *JPRT(I)* identifies the numbers of the junctions for which output is printed. The output for a junction consists of the head at that junction and the flow and velocity for each channel entering that junction.

In Subroutine HYDEX, tables summarizing the data used to create the "hydraulic extract tape" (i.e. tables which summarize the last full tidal cycle of data) are printed. The parameters printed are the (1) net flow in each channel, (2) minimum and maximum junction heads and the cycle of their occurence, (3) the average junction head, (4) the range of junction heads, (5) minimum, maximum, and average channel velocities, (6) minimum, maximum, and average channel flows, and (7) minimum, maximum, and average channel cross-sectional areas.

The printout from HYDEX can be very useful when the model is being applied to a new prototype. The net flow in a channel is helpful in determining whether or not a steady-state solution has been reached. When the solution has converged to steady-state, the net flow in a channel should be equal to the algebraic sum of the flows specified above that channel. The summaries of junction heads and channel velocities are useful when calibrating the hydraulic model because they can be compared to observed tidal elevations and velocities in the prototype.

In Subroutine RESTRT, tables indicating the restart data are printed. These tables contain the junction heads, surface areas, inflows and the channel lengths, widths, depths, cross-sectional areas, roughness coefficient, and velocity existing at the restart cycle *(PUNCYC)*.

Magnetic Tape/Disk Output: Output on Tape or Disk can be obtained in either Subroutine RESTRT or HYDEX.

If execution should terminate prematurely, Subroutine RESTRT will retain a record of the system conditions at the last restart cycle *(PUNCYC)* on Unit 4.

If Subroutine HYDEX is called, a permanent record is made on Unit 4 of the hydraulic parameters needed as input for the quality program (heads, flows, and velocities).

Punched Output: Punched output occurs in Subroutine RESTRT

When Subroutine RESTRT is called, the channel and junction parameters for the final hydraulic cycle can be punched onto a card deck. The format of the deck is such that it can be used as input for a different hydraulic run.

2.2.7 POTENTIAL IMPLEMENTATION DIFFICULTIES

PREMATURE TERMINATION

Before the main computation loop is entered, the hydraulic program checks the compatability of the channel and junction numbering systems. If any discrepancies are found, the program will terminate.

UNSTABLE SOLUTION

Execution of the hydraulic program is terminated if the velocity in any channel exceeds 20 fps, indicating an unstable (diverging) solution. This problem generally arises most frequently during the initial applications of the model to a new system. It can arise, however, even after many successful previous applications, particularly if the hydraulic conditions are significantly different from any previously considered.

An unstable solution usually results from one or more of the following conditions: (1) one or more inputs have been improperly specified (keypunching error, etc.), (2) the stability criterion is violated for a certain channel (indicating the channel length should be increased or the time step decreased), (3) a junction surface area is not properly represented (occurs frequently at dead end channels), or (4) a junction volume is not properly represented (occurs either at dead end channels or in areas such as tidal flats where the depth at low tide may be zero). Under such conditions, unrealistic hydraulic gradients can be created which result in excessive velocities.

The instability can usually be eliminated at dead end channels by increasing the surface area of the end junction somewhat above that indicated on published maps or charts. This tends to eliminate wave reflection caused by the abrupt channel ending. There may be little, if any, wave reflections in the prototype since a real channel rarely ends as abruptly as represented by the model network.

Similarly, in areas such as tidal flats, where the depth at low tide may reach zero, the instability can normally be corrected by increasing the depths of the peripheral channels slightly. As programmed, the model does not adjust the water surface area of a junction as the water rises and falls. There is also no provision for allowing a junction to "run dry" (reach zero depth). However, the model network parameters in these areas may by specified to compensate for these shortcomings. The channel depths and the surface area assigned to the junctions are representative of the mean tide level such that the junction volumes are slightly over-represented at low tide and under-represented at high tide.

STORAGE

For systems represented by a network with a large number of junctions and channels, the length of the record to be stored on Unit 10 may exceed the maximum limit for a magnetic tape, i.e., the tape may be completely filled. For such cases it may be necessary to reprogram the hydraulic program and Subroutine HYDEX to accommodate two tapes rather than one. The reprogramming effort is largely tied to the specification of the starting and stopping points on each tape.

2.2.8. DYNHYD DATA DECK SEQUENCE

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
1	ALPHA(J)	1-80	20A4	2 cards - Identifies the run.
2	HEADER	1-80	20A4	Indicates that Control Data follows.
3	NJ	1-5	I5	
	NC	6-10	I5	
	NCYC	11-15	I5	
	DELT	16-20	F5.0	
	TZERO	21-25	F5.0	
4	IPRINT	1-5	I5	
	INTRVL	6-10	I5	
	NOPRT	11-15	I5	
5	JPRT(1)	1-5	I5	Repeat until NOPRT values are read (read NOPRT/16 of these).
	JPRT(2)	6-10	I5	
	.	.	.	
	.	.	.	
	.	.	.	
6	ITAPE	1-5	I5	
	HYDEXT	6-10	I5	
7	PUNCYC	1-5	I5	
	INTPUN	6-10	I5	
8	HEADER	1-80	20A4	Indicates that Junction Date follows.

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
9	JJ	1-5	I5	Read NJ of these cards.
	Y(J)	6-15	F10.0	
	AREAS(J)	16-25	F10.0	
	QIN(J)	26-35	F10.0	
	NCHAN(J,1)	36-40	I5	
	NCHAN(J,2)	41-45	I5	
	.	.	.	
	.	.	.	
	.	.	.	
	NCHAN(J,5)	56-60	I5	
10	HEADER	1-80	20A4	Indicates that Channel Data follows.
11	NN	1-5	I5	
	CLEN(N)	6-13	F8.0	
	B(N)	14-21	F8.0	
	AREA(N)	22-30	F9.0	
	R(N)	31-37	F7.0	
	(N(N)	38-45	F8.0	
	V(N)	46-53	F8.0	
	NJUNC(N,1)	54-58	I5	
	NJUNC(N,2)	59-63	I5	
12	HEADER	1-80	20A4	Indicates that Seaward Boundary data follows.
13	NK	1-5	I5	

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
14	PERIOD	1-10	I10	
	A1(1)	11-20	F10.0	
	A1(2)	21-30	F10.0	
	.	.	.	
	.	.	.	
	.	.	.	
	A1(NK)	...	F10.0	
15*	HEADER	1-80	20A4	Indicates that HYDEX Data follows.
16*	ALPHA(I)	1-80	20A4	2 cards - Identifies run.
17*	NODYN	1-5	I5	
				* Cards 15, 16, and 17 are read only if Subroutine HYDEX is called (i.e. HYDEXT = 1).

2.2.9 DYNHYD VARIABLE DEFINITIONS

The following pages contain definitions for the major variables in DYNHYD. Variables are listed in alphabetical order. Variables in italics are read from the input data deck.

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
A1(I)	MAIN	Coefficients for tidal input (head) at seaward boundary obtained from program REGAN. (I = 1,NK)	R	
AK(N)	MAIN HYDEX	Frictional coefficient for channel N.	R	
AKT	MAIN	Frictional coefficient during full step computation.	R	
AKT2	MAIN	Frictional coefficient during half step computation.	R	
ALPHA(I)	MAIN HYDEX	Alphanumeric identifier printed as part of output. (I = 1,80)	R	
ARAVG(N)	HYDEX	Mean cross sectional area of channel N over full tidal cycle.	R	ft^2
AREA(N)	MAIN HYDEX RESTRT	Cross sectional area of channel N. Corresponds to the head specified at junctions at ends of the channel.	R	ft^2
AREAS(J)	MAIN HYDEX RESTRT	Surface area of junction J	R	ft^2
AREAT(N)	MAIN	Cross sectional area of channel N during a half time step.	R	ft^2
ARMAX(N)	HYDEX	Maximum cross sectional area of channel N over full tidal cycle.	R	ft^2
ARMIN(N)	HYDEX	Minimum cross sectional area of channel N over full tidal cycle.	R	ft^2
B(N)	MAIN HYDEX RESTRT	Width of channel N.	R	ft

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
CLEN(N)	MAIN HYDEX RESTRT	Length of channel N.	R	ft
CN(N)	MAIN HYDEX RESTRT	Manning roughness coefficient for channel N.	R	
DELT	MAIN HYDEX	Time interval used in solution.	R	secs
DELTQ	HYDEX	Time step for the quality program (DELTQ = DELT * NODYN).	R	secs
DELT2	MAIN	One half time step. (Equals DELT/2)	R	secs
DVDX	MAIN	Defines velocity gradient ($\Delta U/\Delta X$) in a channel.	R	
FLOW	MAIN	Discharge. Follows sign convention used for hydraulic printout.	R	cfs
G	MAIN	Acceleration due to gravity (32.1739 ft/sec^2).	R	ft/sec^2
HEADER	MAIN HYDEX	Alphanumeric identifier for a subsection of the input card deck.	R	
HYDEXT	MAIN	Control Option. If HYDEXT = 1, subroutine HYDEX is called to create a summary hydraulic extract tape and summarize net flows. If HYDEXT = 0, subroutine HYDEX is not called.	I	
ICYC	MAIN RESTRT	Cycle number (iteration) during execution of the quality program.	I	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
ICYCTF	HYDEX	Cycle number stored on unit 4.	I	
INTPUN	MAIN RESTRT	Punch interval for restarting. Restart data is stored on Unit 4 at cycle PUNCYC, and at each INTPUN cycles thereafter.	I	
INTRVL	MAIN	Interval (in cycles) between printouts.	I	
IPRINT	MAIN	Printed output begins at this cycle, and each INTRVL cycles thereafter.	I	
ITAPE	MAIN	Hydraulic parameters are stored on unit 10 beginning at this cycle.	I	
JPRT(I)	MAIN	Specified junctions for which printout is desired. (I = 1,NOPRT).	I	
KTZERO	RESTRT	Variable used temporarily to compute the appropriate value for TZERO in case of restarting	R	
NC	MAIN HYDEX RESTRT	Number of channels in model network.	I	
NCHAN(J,K)	MAIN HYDEX RESTRT	Channel number of the K^{th} channel entering junction J. (K = 1,5)	I	
NCYC	MAIN	Total number of time steps (cycles to be executed).	I	
NCYCC	MAIN HYDEX	Counter for the number of hydraulic cycles.	I	
NEXIT	MAIN	Counter to determine compatability of channels and junctions. If NEXIT is greater than or equal to 1, execution is terminated.	I	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
NJ	MAIN HYDEX RESTRT	Number of junctions in the model network.	I	
NJUNC(N,1)	MAIN HYDEX RESTRT	Lower of the two junction numbers at the ends of channel N.	I	
NJUNC(N,2)	MAIN HYDEX RESTRT	Higher of the two junction numbers at the ends of channel N.	I	
NK	MAIN	Number of coefficients used to specify tidal input. (NK usually equals 7).	I	
NMAX(J)	HYDEX	Hydraulic cycle number at which the maximum head at junction J occurs.	I	
NMIN(J)	HYDEX	Hydraulic cycle number at which the minimum head at junction J occurs.	I	
NODYN	HYDEX	Number of hydraulic time steps per quality time step.	I	
NOPRT	MAIN	Number of junctions for which output is desired.	I	
NS	MAIN	NK/2. Number of Sine (and Cosine) terms in relationship defining tidal input.	I	
NSTART	HYDEX	Starting cycle on the hydraulic extract tape. (Unit 4).	I	
NSTOP	HYDEX	Ending cycle on the hydraulic extract tape. (Unit 4).		

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
PERIOD	MAIN HYDEX RESTRT	Period of the tidal input. PERIOD is read in as hours, but transformed to seconds within the program.	R	
PUNCYC	MAIN RESTRT	RESTRT is called at cycle PUNCYC and every INTPUN cycles thereafter.	I	
Q(N)	MAIN HYDEX	Flow in channel N.	R	cfs
QEXT(N)	HYDEX	Mean flow in channel N over each quality time step.	R	cfs
QIN(J)	MAIN HYDEX RESTRT	Inflow or withdrawl at junction J. Inflows must be specified as negative numbers, while withdrawls must be positive numbers	R	cfs
QMAX(N)	HYDEX	Maximum flow in channel N over full tidal cycle.	R	cfs
QMIN(N)	HYDEX	Minimum flow in channel N over full tidal cycle.	R	cfs
QNET(N)	HYDEX	Net flow in channel N over full tidal cycle.	R	cfs
R(N)	MAIN HYDEX RESTRT	Hydraulic radius of channel N, taken as the channel depth.	R	ft.
RANGE(J)	HYDEX	The tidal range at junction J. RANGE(J) = YMAX(J) - YMIN(J).	R	ft.
SUMQ	MAIN	Net flow into or out of a junction.	R	
T	MAIN	Total elapsed time. Initialized to equal TZERO and is incremented by DELT at the start of each time step.	R	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
T2	MAIN	Total elapsed time for one half step computations. T2 lags T by DELT2.	R	
TZERO	MAIN	Time at which computations begin, Allows starting point to be anywhere on tidal cycle.	R	
TZERO2	RESTRT	Variable used temporarily to compute the appropriate value for TZERO in case of restarting.	R	
V(N)	MAIN HYDEX RESTRT	Mean velocity in channel N.	R	
VEL	MAIN	Velocity. Follows sign convention used for hydraulic outputs.	R	fps
VEXT(N)	HYDEX	Mean velocity in channel N over each quality time step.	R	
VMAX(N)	HYDEX	Maximum velocity in channel N over tidal cycle. If flow reversal occurs in channel N, VMAX(N) will be the maximum positive velocity.	R	
VMIN(N)	HYDEX	Minimum velocity in channel N over tidal cycle. If flow reversal occurs in channel N, VMIN(N) will be the maximum negative velocity	R	
VT(N)	MAIN	Velocity in channel N during half time step.	R	fps
W	MAIN	2π/PERIOD	R	
Y(J)	MAIN HYDEX RESTRT	Head at junction J.	R	ft.
YAVG(N)	HYDEX	Mean head at junction J over tidal cycle.	R	ft.

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
YMAX(N)	HYDEX	Maximum head at junction J over tidal cycle.	R	ft.
YMIN(N)	HYDEX	Minimum head at junction J over tidal cycle.	R	ft.
YNEW(N)	HYDEX	New name for head at junction J to differentiate it from the head at the same junction at another time step.	R	ft.
YT(J)	MAIN	Head a junction J during one half time step.	R	ft.
Unit 4	HYDEX RESTRT	Serves as restart device in case of premature termination of execution. Otherwise, it is used as the hydraulic extract tape, created to store data for input to the quality program.		
Unit 5	MAIN HYDEX	Used for card input (card reader).		
Unit 6	MAIN HYDEX RESTRT	Used for printed output (printer).		
Unit 8	RESTRT	Used for punched output (card punch).		
Unit 10	MAIN HYDEX	Serves as a temporary record of the hydraulic solution. Pertinent hydraulic parameters are stored for every channel and junction for every cycle beyond ITAPE.		

2.3 COMPUTER REQUIREMENTS

2.3.1 IBM JOB CONTROL LANGAUGE (JCL)

The JCL used to execute program REGAN is as follows

```
//JOB CARD
//EXEC FORTGCLG
//FORT.SYSIN DD *
     program REGAN goes here
//GO.FT06001 DD SYSOUT=A
//GO.SYSIN DD *
     data deck goes here
/*EOF
```

The JCL used to execute program DYNHYD is as follows

```
   //JOB CARD
   //STEP1 EXEC PGM=DYNHYD
   //STEPLIB DD DISP=SHR,VOL=(PRIVATE,RETAIN,SER=REGNA3),
   //  UNIT=3330-1,DSN=CNQSQM.LJC.CLARKLIB
--------------------------------------------------------------------
   //GO.FT04001 DD DCB=(RECFM=VS,LRECL=504,BLKSIZE=5040,          stores
   //  DISP=(NEW,KEEP,KEEP),VOL=SER=USER99,UNIT=3330-1,             on
   //  DSN=CN.EPAXYZ.ACCT.DATA.SET.NAME                              disk
                                  or
   //GO.FT04001 DD DCB=(RECFM=VS,LRECL=504,BLKSIZE=5040),         stores
   //  DISP=(NEW,KEEP,KEEP),VOL=SER=TAPE##,UNIT=2400,                on
   //  DSN=LEOTAPE,LABEL=(##,SL,EXPDT=98000)                        tape
--------------------------------------------------------------------
   //DD DSN=SYS2.FTGILINK,DISP=SHR
   //GO.FT10F001 DD DSN=&&HYDTA,DCB=(RECFM=VS,LRECL=504,BLKSIZE=5040),
   //  DISP=(NEW,DELETE,DELETE),SPACE=(TRK,(40,40)),UNIT=SYSDA
   //GO.FT08F001 DD DUMMY
   //GO.FT06F001 DD SYSOUT=A
   //GO.FT05F001 DD *
        data deck here
  /*EOF
```

2.3.2 UNIVAC EXECUTIVE CONTROL LANGAUGE (ECL)

The ECL used to execute program REGAN is as follows

```
@RUN CARD
@PASSWORD
@SYM
@FTN,IS
   program REGAN goes here
@MAP,I
LIB FTN*RLIB
@XQT
   data deck goes here
@FIN
```

The ECL used to execute program DYNHYD is as follows

```
@RUN CARD
@PASSWORD
@SYM
@ASG,A  USERID*PGMFILE.
@COPY,A  USERID*PGMFILE.DYNHYD
@FREE  USERID*PGMFILE.
@ASG,T  USERID*TEMPFILE
@USE  10.,USERID*TEMPFILE
@ASG,CP  USERID*1500CFS
@USE  4.,USERID*1500CFS
@XQT  DYNHYD
   data deck goes here
@FIN
```

2.3.3 EXECUTION TIMES

The time required to execute the hydraulic program is dependent on the computer used, the network size, the computational time step, and the length of the run. Typical execution times for DYNHYD are given in Table 2.1 below. DYNHYD requires approximately 130K of storage for execution.

Junctions	Channels	Time Step (secs)	Length of run (hrs)	Execution Time (mins)	Computer
112	170	50	37.5	5	CDC 6600
112	170	50	50.0	8	CDC 6600
112	170	50	25.0	8	IBM 360/65
129	131	90	50.0	1.3	IBM 370/168
133	139	90	25	.8	IBM 370/168
247	306	75	12.5	4	CDC 6600
830	1050	100	25	12	CDC 6600
133	139	90	50	2.4	UNIVAC 1100

TABLE 2.1 DYNHYD EXECUTION TIMES

CHAPTER 3

IMPLEMENTATION OF THE WATER QUALITY MODEL - DYNQUAL

3.1 THE "MAIN" PROGRAM

As mentioned previously, the water quality program (DYNQUAL) uses data created by the hydraulic program as input. Figure 3.1 shows the relationships between the hydraulic and the quality programs and subroutines.

Figures 3.2 and 3.3 are flowcharts depicting the sequence of steps for the MAIN program of DYNQUAL. A brief description of the program logic is as follows:

STEP 1 - READ SYSTEM INFORMATION FROM HYDRAULIC TAPE

Alphanumeric data is read which identifies: the purpose of the run *(ALPHA (I))*, the network size *(NJ and NC)*, the starting *(NSTART)* and ending *(NSTOP)* cycles on the hydraulic extract tape (Unit 4) created by the hydraulic program, and the number of hydraulic time steps per quality time step *(NODYN)*. The hydraulic extract tape (Unit 4) is then read and copied onto a scratch disk (Unit 3) for use by the quality program.

STEP 2 - READ INDEPENDENT CONTROL DATA

Alphanumeric data is read which defines: (1) control parameters such as the hydraulic cycle at which the quality program is to begin reading the hydraulic data *(HYDCYC)*, length of quality run *(NQCYC)*, the number of quality cycles per tidal period *(NSPEC)*, the number of constituents to be modeled *(NUMCON)*, the temperature *(TEMP)*, and other control options, (2) tabular output control parameters specifying the types of tables and the cycles at which they occur, and (3) plotting output control parameters specifying the types of plots to be printed. A table summarizing many of these control parameters

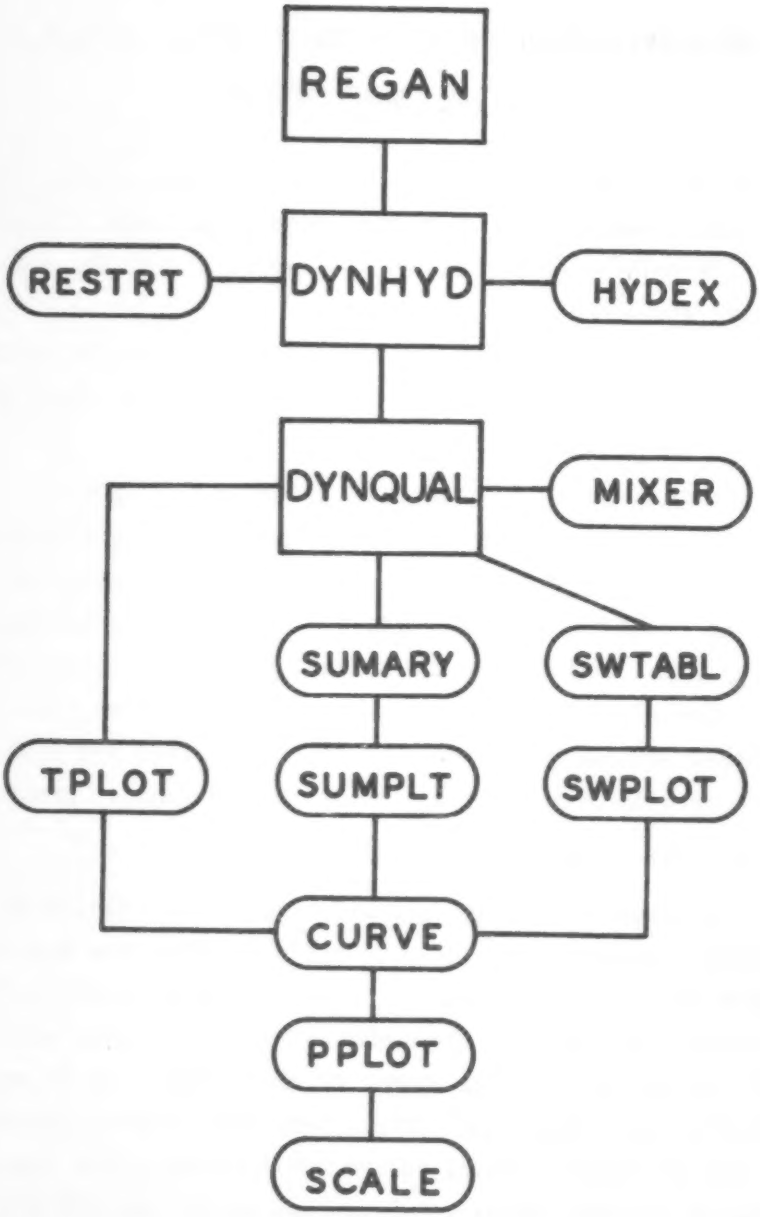
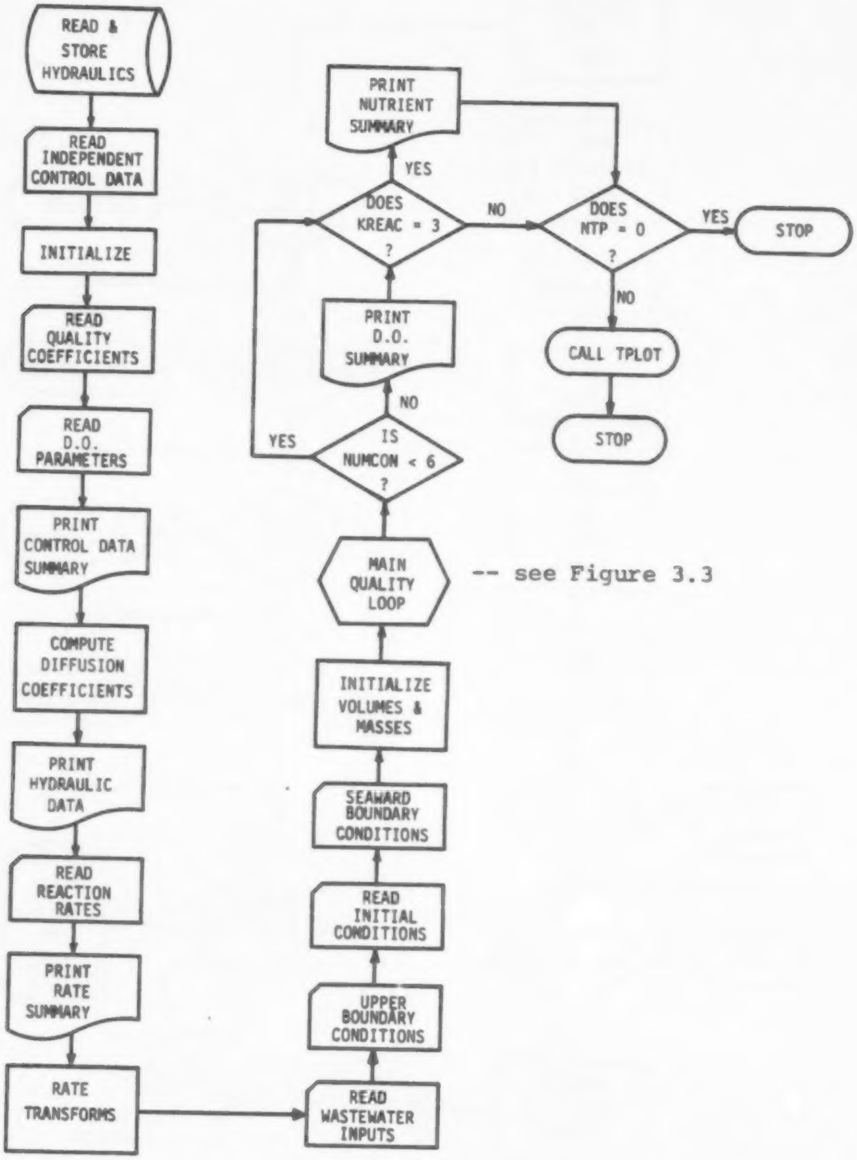

REGAN
DYNHYD
RESTRT
HYDEX
DYNQUAL
MIXER
SUMARY
SWTABL
TPLOT
SUMPLT
SWPLOT
CURVE
PPLOT
SCALE

FIGURE 3.1 PROGRAM AND SUBROUTINE LINKAGES OF THE DEM


READ & STORE HYDRAULICS
READ INDEPENDENT CONTROL DATA
INITIALIZE
READ QUALITY COEFFICIENTS
READ D.O. PARAMETERS
PRINT CONTROL DATA SUMMARY
COMPUTE DIFFUSION COEFFICIENTS
PRINT HYDRAULIC DATA
READ REACTION RATES
PRINT RATE SUMMARY
RATE TRANSFORMS
READ WASTEWATER INPUTS
UPPER BOUNDARY CONDITIONS
READ INITIAL CONDITIONS
SEAWARD BOUNDARY CONDITIONS
INITIALIZE VOLUMES & MASSES
MAIN QUALITY LOOP
IS NUMCON < 6 ?
YES
NO
PRINT D.O. SUMMARY
DOES KREAC = 3 ?
YES
NO
PRINT NUTRIENT SUMMARY
DOES NTP = 0 ?
YES
STOP
NO
CALL TPLOT
STOP

-- see Figure 3.3

FIGURE 3.2 FLOWCHART OF THE MAIN PROGRAM IN DYNQUAL

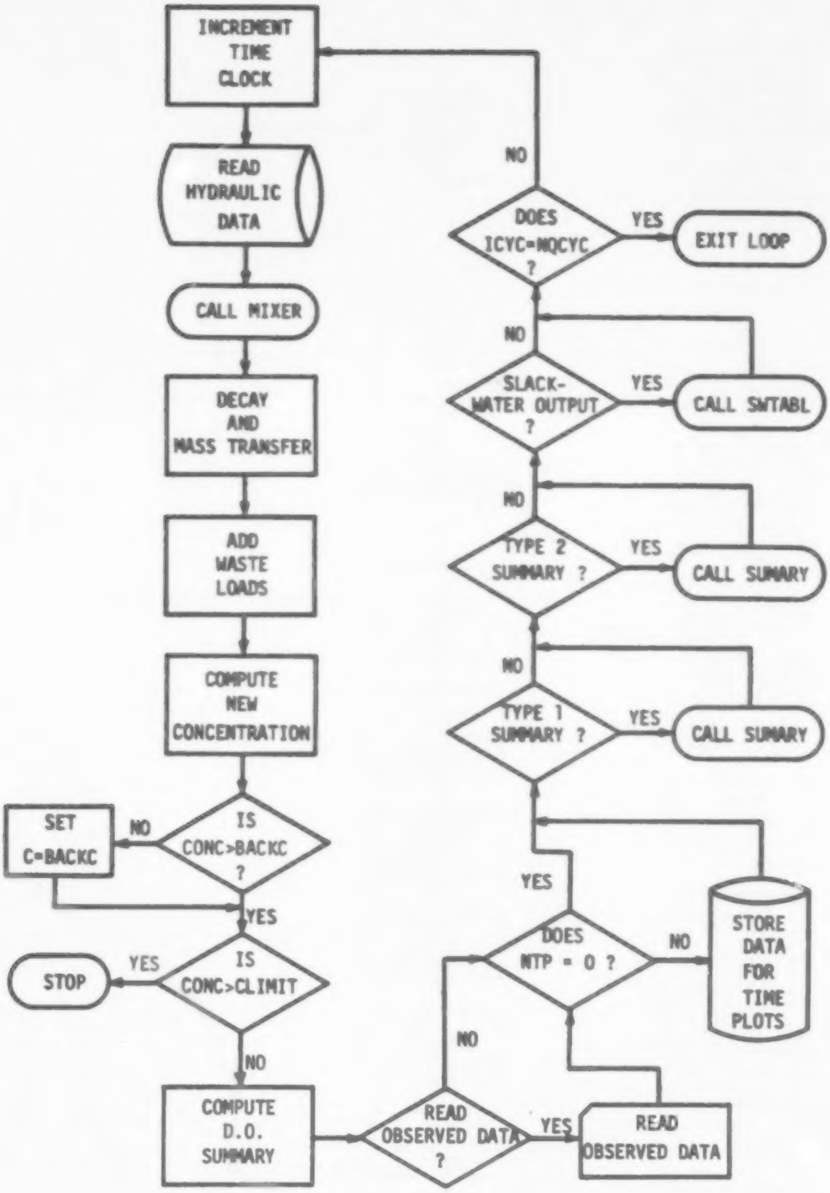

INCREMENT TIME CLOCK
READ HYDRAULIC DATA
CALL MIXER
DECAY AND MASS TRANSFER
ADD WASTE LOADS
COMPUTE NEW CONCENTRATION
IS CONC>BACKC ?
NO
SET C=BACKC
YES
IS CONC>CLIMIT
YES
STOP
NO
COMPUTE D.O. SUMMARY
READ OBSERVED DATA ?
YES
READ OBSERVED DATA
NO
DOES NTP = 0 ?
NO
STORE DATA FOR TIME PLOTS
YES
TYPE 1 SUMMARY ?
YES
CALL SUMARY
NO
TYPE 2 SUMMARY ?
YES
CALL SUMARY
NO
SLACK-WATER OUTPUT ?
YES
CALL SWTABL
NO
DOES ICYC=NQCYC ?
YES
EXIT LOOP
NO

FIGURE 3.3 FLOWCHART OF THE MAIN QUALITY LOOP

will be printed in Step 6. If any plots are to be outputted, the maximum *(YMAXC (K))* and minimum *(YMINC (K))* values for constituent K on the y-axis (ordinate) and the points along the x-axis (abscissa) corresponding to the network junctions *(RMNODE (J))* are specified.

STEP 3 - INITIALIZE VARIABLES

Initial values required for certain variables (e.g. counters) are set. At this point, the junction numbers at each end of a channel are checked to insure that *NJUNC (N,1)* refers to the lower junction number for channel N and that *NJUNC (N,2)* refers to the higher junction number (at the other end of channel N).

If slack water tables are desired, Subroutine SWTABL (see Section 3.4) is called to initialize the parameters internal to this subroutine.

STEP 4 - READ QUALITY COEFFICIENTS

Alphanumeric data is read for each constituent which describes the constituent name *(CNAME)*, its minimum and maximum concentrations *(BACKC* and *CLIMIT)*, and its temperature correction coefficient *(THETA)*.

STEP 5 - READ DISSOLVED OXYGEN (CONSTITUENT 6) PARAMETERS

Alphanumeric data is read which defines the time of sunrise *(TSRISE)*, time of sunset *(TSSET)*, photosynthesis rates *(PHOT)*, respiration rates *(RES)*, photic depths *(DEPTH)*, benthic demand rates *(BENT)*, and reaeration coefficients *(A, W, X)* throughout the estuary.

STEP 6 - PRINT CONTROL DATA

A table is printed listing several of the parameters inputted in steps 1 through 5.

STEP 7 - COMPUTE DIFFUSION COEFFICIENTS

The constant *(CDIFFK)* used to compute the diffusion coefficients *(DIFFK)* throughout the estuary are read and the diffusion coefficients for each channel are determined. (See Section 3.2).

STEP 8 - PRINT NETWORK AND HYDRAULIC PARAMETERS

A table summarizing the hydraulic parameters stored on the hydraulic extract tape is printed. The diffusion constants *(CDIFFK)* for each channel are also printed.

STEP 9 - READ REACTION RATES

Alphanumeric data is read which defines the characteristics and linkages of the quality constituents. (A more detailed discussion of constituent linkages is found in Section 3.8). Tables summarizing these parameters are printed.

STEP 10 - RATE TRANSFORMATIONS

The inputted rates are adjusted so that they (1) correspond to a quality time step (2) correspond to the assumed temperature, and (3) determine the amount of material decayed or regenerated during a time step instead of the amount of material remaining after a time step.

STEP 11 - WASTEWATER INPUTS

Alphanumeric data is read which specifies (1) the number of constant waste inputs *(NWASTC)*, i.e. an input whose flow rate and concentrations are constant, (2) the number of variable waste inputs *(NWASTV)*, i.e. an input whose flow rate and/or concentrations vary with time, and a description of how the flows and concentrations vary, and (3) the number of variable bank load inputs *(NBANK)*, i.e. a load from a junction shoreline (e.g. runoff), the length of each junction's shoreline, the junctions receiving the variable bank loads, and a description of how the flows and concentrations vary over time. Tables summarizing the above inputs are printed.

STEP 12 - UPPER BOUNDARY CONDITIONS

Data is read which describes how the flows and constituent concentrations at the upper boundary of the model network vary with time. A table summarizing this data is printed.

STEP 13 - INITIAL CONDITIONS

The initial concentration for every constituent in every junction is specified. A table summarizing this data is printed.

STEP 14 - SEAWARD BOUNDARY CONDITIONS

Data is read which describes how the concentration of every constituent varies over a tidal cycle at the seaward boundary. A table summarizing this data is printed.

STEP 15 - INITIALIZE VOLUMES AND MASSES

The mean volume of each junction (corresponding to zero head) is computed based on the average depth computed in the hydraulic run. Unit 3 is aligned at the hydraulic cycle at which the quality run begins *(HYDCYC)* and the junction heads are read. The mean junction volumes are then adjusted to the new heads in order to establish the junction volumes at the start of the quality run.

The initial mass of every constituent in every junction is computed. The diffusion constant of every channel and the volume of all inflows/outflows at each junction over a quality time step are computed.

STEP 16 - MAIN QUALITY LOOP

This loop is executed for every cycle of the quality program. First the "clock time" *(CTIME)* is incremented by a quality time step *(DELTQ1)*. Next, the hydraulic parameters (flows, velocities, and heads) for the current cycle are read from Unit 3. If the last hydraulic cycle read was the last hydraulic cycle stored on Unit 3, then Unit 3 is rewound.

Subroutine MIXER (Section 3.2) is called to determine the mass of each constituent transferred between junctions by advection and diffusion.

The reaction rates defined in Step 9 are applied to their respective constituents in every junction.

Constant waste, variable waste, variable bank, and upper boundary loads are added to the appropriate junctions.

Junction volumes are adjusted to the start of the next time step and new constituent concentrations are computed by dividing the mass of each constituent in a junction by the junction volume. If the predicted concentration of constituent K is less than the minimum allowable concentration *(BACKC(K))*, the constituent concentration is set equal to *BACKC(K)* and the corresponding mass is specified for the junction. If *KDCOP*=1, a statement that the adjustment was made will be printed. If the predicted concentration exceeds the maximum allowable concentration *(CLIMIT(K))*, execution is terminated.

A special analysis is made of constituent 6 (dissolved oxygen for the version herein). The minimum *(DOMIN(J))* and maximum *(DOMAX(J))* concentrations, as well as the cycles of their occurrence *(MINCYC(J)* and *MAXCYC(J))*; the average concentrations*(DOAVG(J))*; and the number of cycles in which the concentration is below 4.0 mg/l *(DOLT4(J))*, between 4.0 mg/l and 5.0 mg/l *(DO4TO5(J))*, and above 5.0 mg/l *(DOGT5(J))* are computed for every junction. This analysis starts at cycle *NDOCYC* and continues until the end of the quality run.

A check is made to determine if observed data *(OBDATA(I,J,K))*, which will appear on certain plots, is to be read at the present cycle.

A check is made to determine if any time history plots are to be printed. If so, the constituent concentrations for the appropriate junctions are stored on Unit 11.

A check is made to determine if subroutine SUMARY (Section 3.3) is to be called to compute a summary of the predicted concentrations for a specified period.

A check is made to determine if subroutine SWTABL (Section 3.4) is to be called to output the current concentrations in a slack water table.

STEP 17 - EXIT LOOP

After *NQCYC* cycles have been completed, the Main Quality Loop is left. A table summarizing the constituent 6 analysis is printed. If *KREAC* = 3 (i.e. if both constituent 1 and constituent 3 are considered in determining the growth of constituent 4), a table summarizing the number of cycles for which each constituent limited growth is printed.

A check is made to determine if subroutine TPLOT (Section 3.6) is to be called to output time plots

3.2 SUBROUTINE MIXER

This subroutine computes the amount of mass transferred between junctions due to the processes of advection and diffusion. For every channel in the system, the advected and diffused masses are computed and are transferred from the junction at one end of the channel to the junction at the opposite end of the channel. A simplified flowchart depicting the sequence of steps in MIXER is shown in Figure 3.4. The logic of the subroutine is as follows:

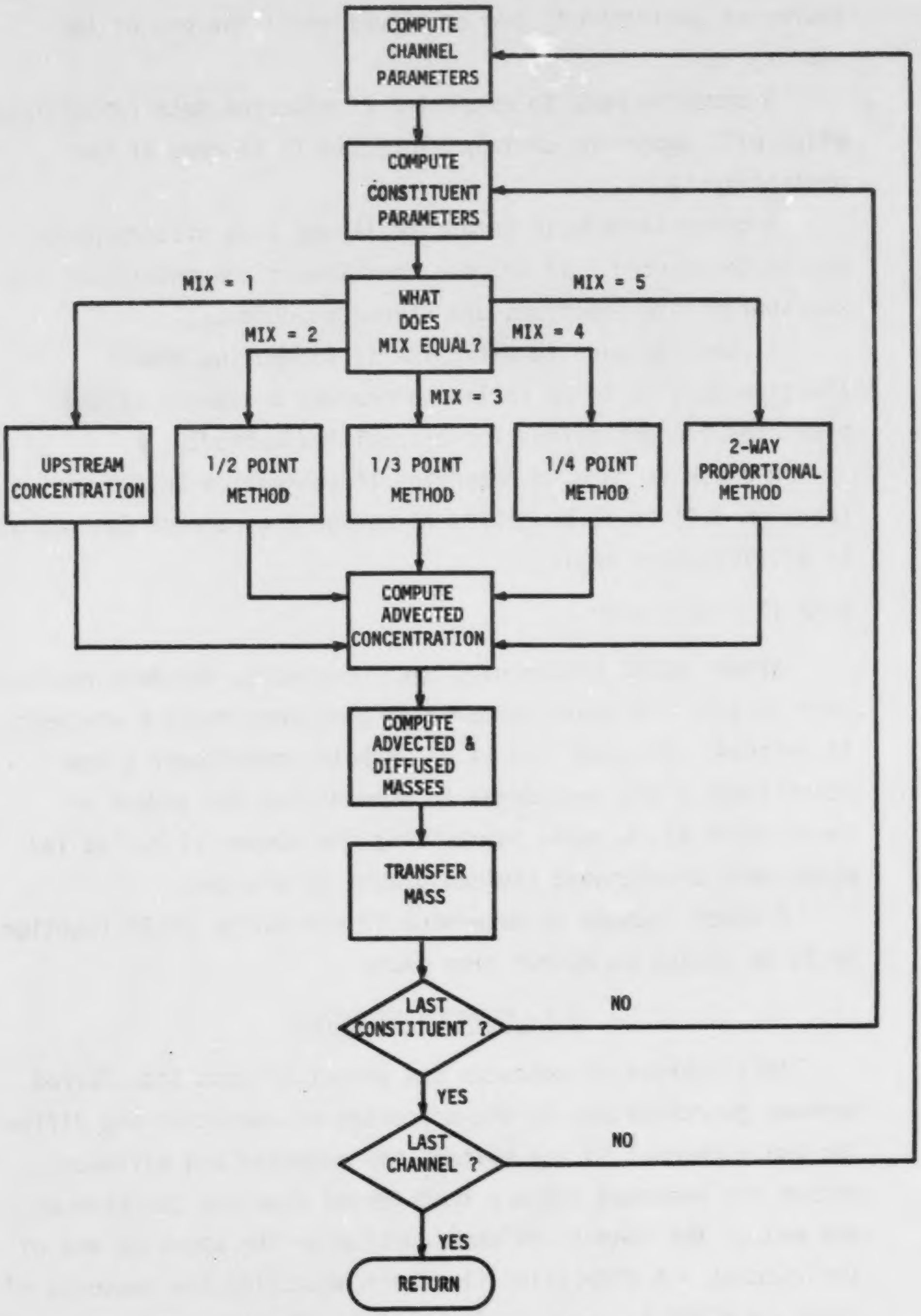

COMPUTE CHANNEL PARAMETERS
COMPUTE CONSTITUENT PARAMETERS
WHAT DOES MIX EQUAL?
MIX = 1
MIX = 2
MIX = 3
MIX = 4
MIX = 5
UPSTREAM CONCENTRATION
1/2 POINT METHOD
1/3 POINT METHOD
1/4 POINT METHOD
2-WAY PROPORTIONAL METHOD
COMPUTE ADVECTED CONCENTRATION
COMPUTE ADVECTED & DIFFUSED MASSES
TRANSFER MASS
LAST CONSTITUENT ?
NO
YES
LAST CHANNEL ?
NO
YES
RETURN

FIGURE 3.4 FLOWCHART OF SUBROUTINE MIXER

STEP 1 - COMPUTE CHANNEL PARAMETERS

The volume of fluid transported through a channel during a time step *(VOLFLW)* is computed. The channel diffusion coefficient *(DIFFC)* is also calculated.

STEP 2 - COMPUTE CONSTITUENT PARAMETERS

The variable *CA* is defined as the concentration in the junction with the lower junction number *(NJUNC(N,1))*. Variable *CB* is defined as the concentration in the junction at the opposite end of the channel *(NJUNC(N,2)*.

STEP 3 - COMPUTE ADVECTED MASS

The concentration of the constituent in the water being advected *(CONC)* can be determined several ways. The variable *MIX* defines the method used to compute *CONC*, where:

1 - use upstream concentration
2 - use 1/2 point method
MIX = 3 - use 1/3 point method
4 - use 1/4 point method
5 - use 2-way proportional method

The mass of constituent transferred by advection is found by multiplying the volume of fluid advected *(VOLFLW)* by the concentration in the advected fliud *(CONC)*.

STEP 4 - COMPUTE DIFFUSED MASS

The mass of constituent transferred by diffusion is computed by multiplying the concentration gradient *(CA - CB)* by the diffusion coefficient *(DIFFK)*.

STEP 5 - TRANSFER ADVECTED AND DIFFUSED MASSES

The direction of the transfer of mass by advection is dependent on the direction of flow in the channel. Flow in a channel will usually be leaving one junction and entering another. The advected mass is subtracted from the junction in which the flow is leaving and is added to the junction in which the flow is entering.

The transfer of mass by diffusion is dependent on the concentration gradient. Mass will move from the junction with the higher concentration to the junction with the lower concentration. In other words, the diffused mass is subtracted from the junction with the higher concentration and added to the junction with the lower concentration.

3.3 SUBROUTINE SUMARY

This subroutine prints out the minimum, maximum and average constituent concentrations predicted during specified time intervals. In order to allow summary periods which overlap, SUMARY can compute a "Type 1" summary and a "Type 2" summary. Type 1 summaries can overlap Type 2 summaries (and vice versa), otherwise, they are identical. A flowchart depicting the logic of SUMARY is shown in Figure 3.5. A description of the program logic is as follows:

STEP 1 - DETERMINE TYPE OF SUMMARY

A check is made to determine which type of summary (Type 1 or Type 2) is desired. If $NUM = 1$, a Type 1 summary is desired. If $NUM = 2$, a Type 2 summary is desired.

STEP 2 - INITIALIZE

If the current cycle is the first cycle of the summary period *(IP)*, the minimum, maximum, and average concentrations for each junction are set equal to the current junction concentrations. If not, Step 3 is executed.

STEP 3 - DETERMINE MINIMUM, MAXIMUM, AND AVERAGE CONCENTRATIONS

For every cycle within the summary period, checks are made to determine the minimum, maximum, and average concentrations during the period.

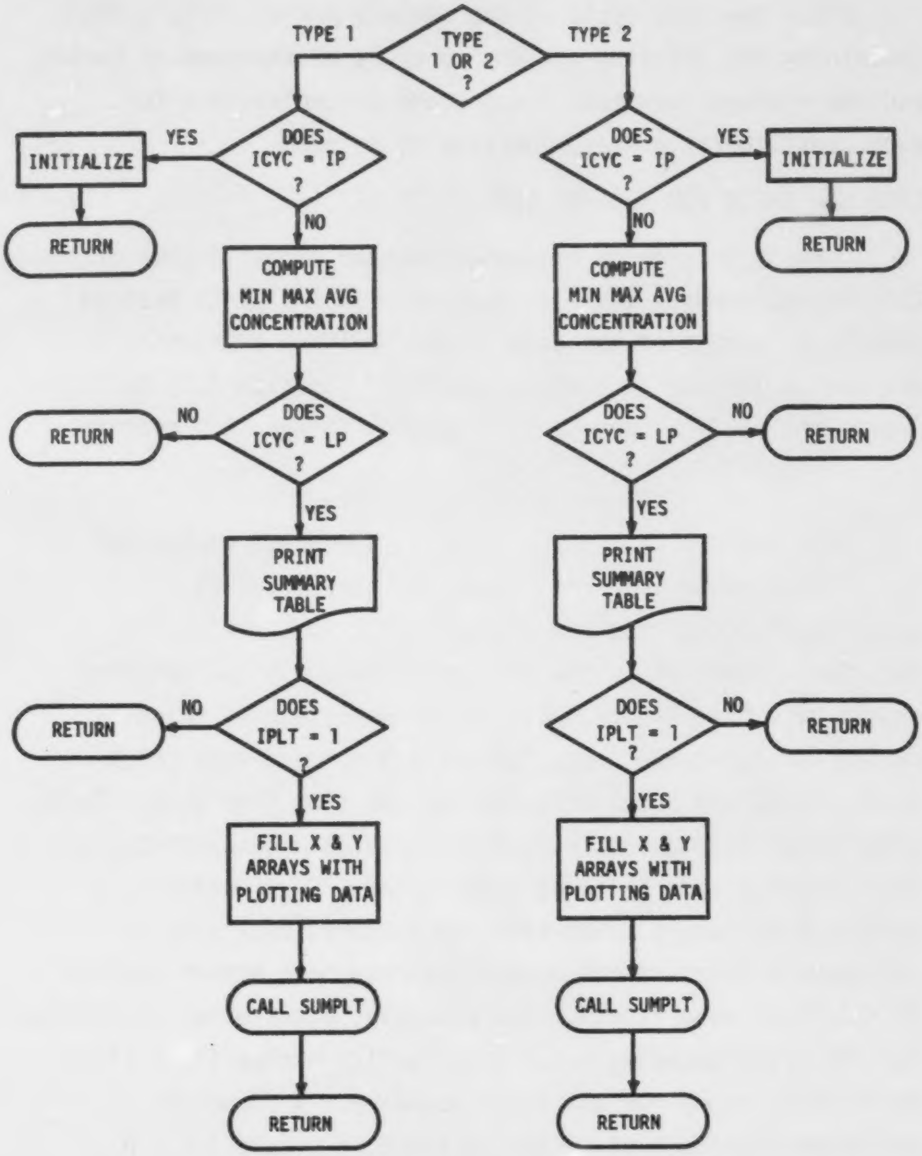

TYPE 1
TYPE 1 OR 2 ?
TYPE 2
DOES ICYC = IP ?
YES
NO
INITIALIZE
RETURN
COMPUTE MIN MAX AVG CONCENTRATION
DOES ICYC = LP ?
NO
YES
RETURN
PRINT SUMMARY TABLE
DOES IPLT = 1 ?
NO
YES
RETURN
FILL X & Y ARRAYS WITH PLOTTING DATA
CALL SUMPLT
RETURN

FIGURE 3.5 FLOWCHART OF SUBROUTINE SUMARY

STEP 4 - OUTPUT SUMMARY TABLE

After the last cycle of the summary period *(LP)*, a table containing the starting and ending cycle of the summary period and the minimum, maximum, and average concentrations for each constituent in every junction is printed.

STEP 5 - CHECK FOR PLOT OF SUMMARY TABLE

A check is made to determine whether or not a plot of the current summary table is desired. If a plot is desired *(PLT = 1)*, arrays of the data *(FGQXA(NPP)* and *FGQXO(NPP,LPP))* are set up for use by Subroutine SUMPLT (Section 3.5) to create the plots. Control then returns to the MAIN program.

3.4 SUBROUTINE "SWTABL"

This subroutine sets up slack water output tables for specified time periods and prints the corresponding constituent concentrations. Slack water at a particular location is defined as the time at which the tidal velocity equals zero (see Figure 3.6). Slack water occurs twice during a tidal cycle, once following the flood tide (high water slack) and once following the ebb tide (low water slack). Slack water output consists of the predicted concentrations at a junction when it is at slack water. Slack water occurs at different times along an estuary, beginning at the seaward boundary and moving upstream in a manner similar to the tidal wave itself. Consequently, slack water predictions for the upper boundary occur many quality cycles after slack water predictions for the lower boundary. A flowchart depicting the logic of SWTABL is shown in Figure 3.7. A description of the program logic is as follows:

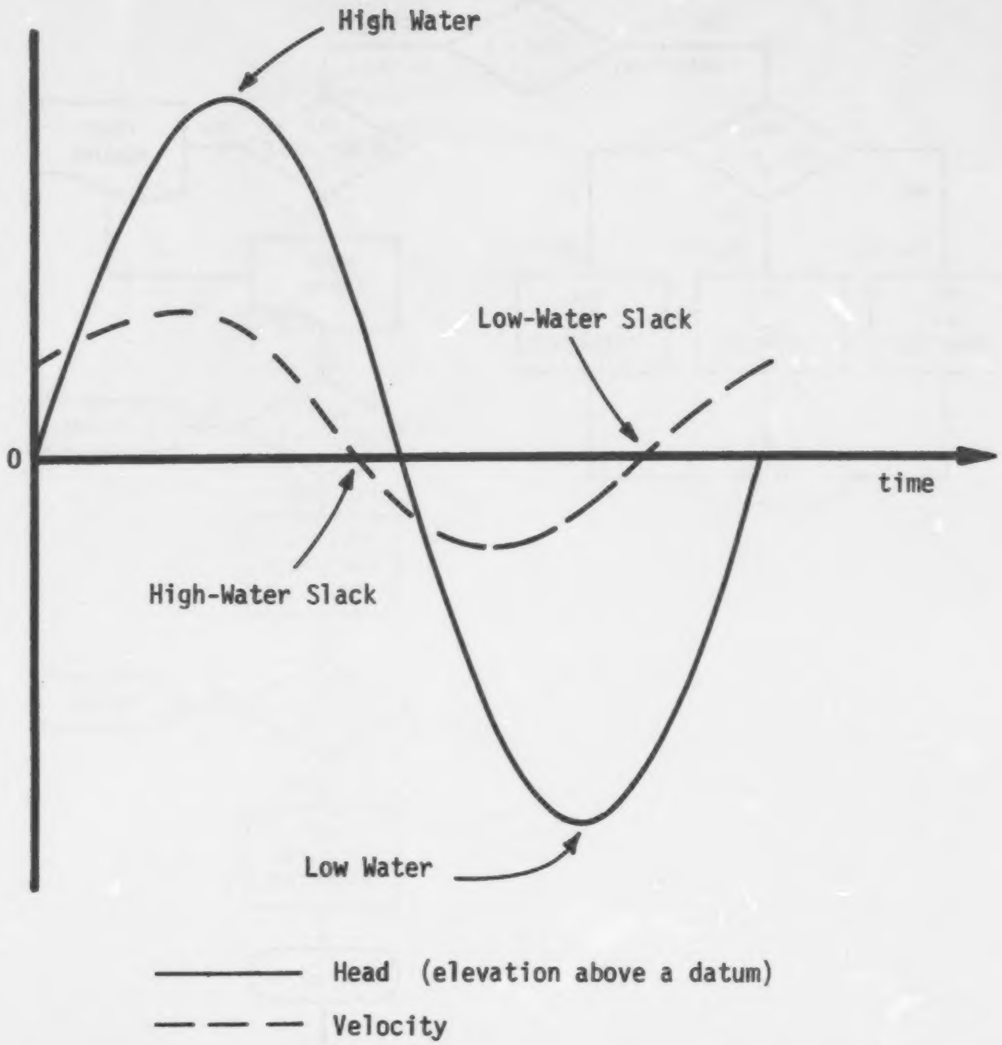


FIGURE 3.6 LOCATION OF HIGH & LOW WATER SLACKS

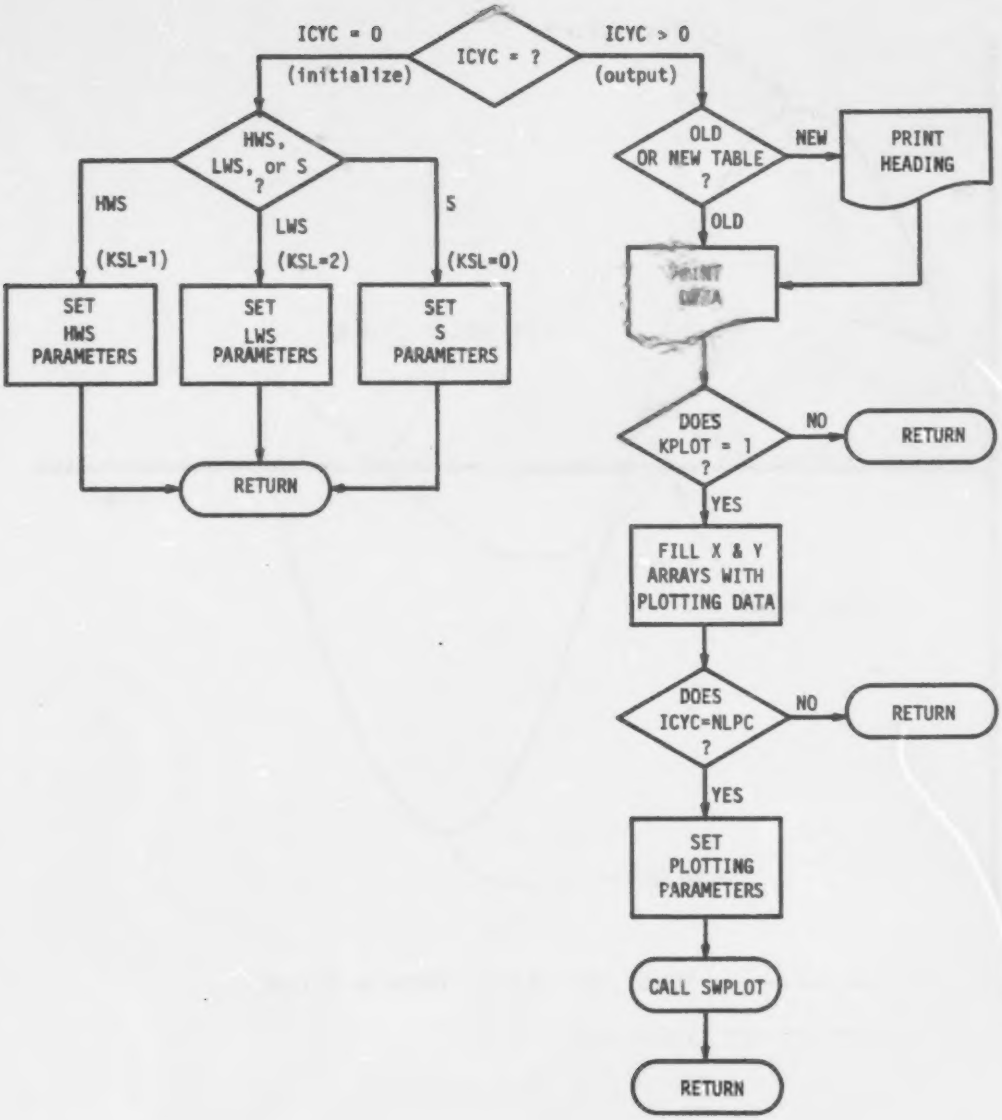

ICYC = 0
(initialize)
ICYC = ?
ICYC > 0
(output)
HWS, LWS, or S ?
HWS
(KSL=1)
LWS
(KSL=2)
S
(KSL=0)
SET HWS PARAMETERS
SET LWS PARAMETERS
SET S PARAMETERS
RETURN
OLD OR NEW TABLE ?
NEW
PRINT HEADING
OLD
PRINT DATA
DOES KPLOT = 1 ?
NO
RETURN
YES
FILL X & Y ARRAYS WITH PLOTTING DATA
DOES ICYC=NLPC ?
NO
RETURN
YES
SET PLOTTING PARAMETERS
CALL SWPLOT
RETURN

FIGURE 3.7 FLOWCHART OF SUBROUTINE SWTABL

STEP 1 - CHECK FOR SET-UP OR OUTPUT OF TABLES

SWTABL is actually called at two points in the quality program. First, it is called during the initialization portion of the MAIN program. Here, it determines the type of tables (high water slack (HWS), low water slack (LWS), or snapshot) and their corresponding parameters (the junctions to be printed and when). To do this, the model junctions are divided into several groups, each of which is at slack water at approximately the same time. This grouping can be accomplished by studying detailed hydraulic outputs and determining when and where the velocities in the estuary are zero. If the junctions were divided into ten groups, then slack water would occur at the junctions in group 1 first, say at cycle J. Slack water would occur at the junctions in group 2 one cycle later (i.e. at cycle J + 1), at the junctions in group 3 two cycles later (cycle J + 2), etc. The junctions within the groups vary, depending on whether a HWS, LWS, or snapshot table is desired. This is due to the differences between high and low water slack conditions. The variables *NSWCYC*, *NOPRT(I)*, and *JPRT(I,N)* describe a slack water table. *NSWCYC* is the difference in time (in cycles) between the occurence of slack water at the upper and lower boundaries, *NOPRT(I)* is the number of junctions in the I^{th} group, and *JPRT(I,N)* is the number of the N^{th} junction in group I. A snapshot table is not a slack water table in the true sense of the term. Rather, it divides the junctions into only one group and outputs the concentrations for all the junctions in the group at one specified cycle, hence the term "snapshot". SWTABL is called again during the main computational loop in the MAIN program. Here, it outputs the tables as they were set up earlier. The output is obtained by sequentially printing the predicted concentrations for the junctions within each group. Hence, if group I was at slack water during cycle J, then the concentrations for the junctions within group I are printed at cycle J, the concentrations for the junctions within group I + 1 are printed at cycle J + 1, and so on.

STEP 2 - CHECK FOR PLOT

A check is made to determine whether or not a plot of the current slack water table is desired. If *KPLOT(M)* = 0, a plot is not desired, and control returns to the MAIN program (See Section 3.10 for plotting options.). If so, the predicted concentrations are stored in arrays *(FGSWA(NPP)* and *FGSWO(NPP,LPP))* until the slack water table is completed, at which point subroutine SWPLOT is called to produce the plot. Control then returns to the MAIN program.

3.5 SUBROUTINES SUMPLT AND SWPLOT

These subroutines link the tabular output subroutines (SUMARY and SWTABL) to the generalized printer plot routines (CURVE, PLOT, and SCALE). A flowchart depicting the logic of SUMPLT and SWPLOT is shown in Figure 3.8. Both subroutines follow the same sequence of steps:

STEP 1 - SET LABELS ON SIDE AND BOTTOM AXES

The labels (e.g. "Miles Below Chain Bridge") on the x-axis *(BOTTOM(I))* and the labels (e.g. "Constituent") on the *y*-axis are set.

STEP 2 - THE X AND Y ARRAYS ARE CREATED

These arrays are created using the arrays (of predicted concentrations) set up in SUMPLT (or SWPLOT) and will be used in the plotting routines to generate the plots.

STEP 3 - SET SIDE LABELS FOR CONSTITUENT

The constituent number for each plot is added to the y-axis label (e.g. "Constituent" becomes "Constituent 1"

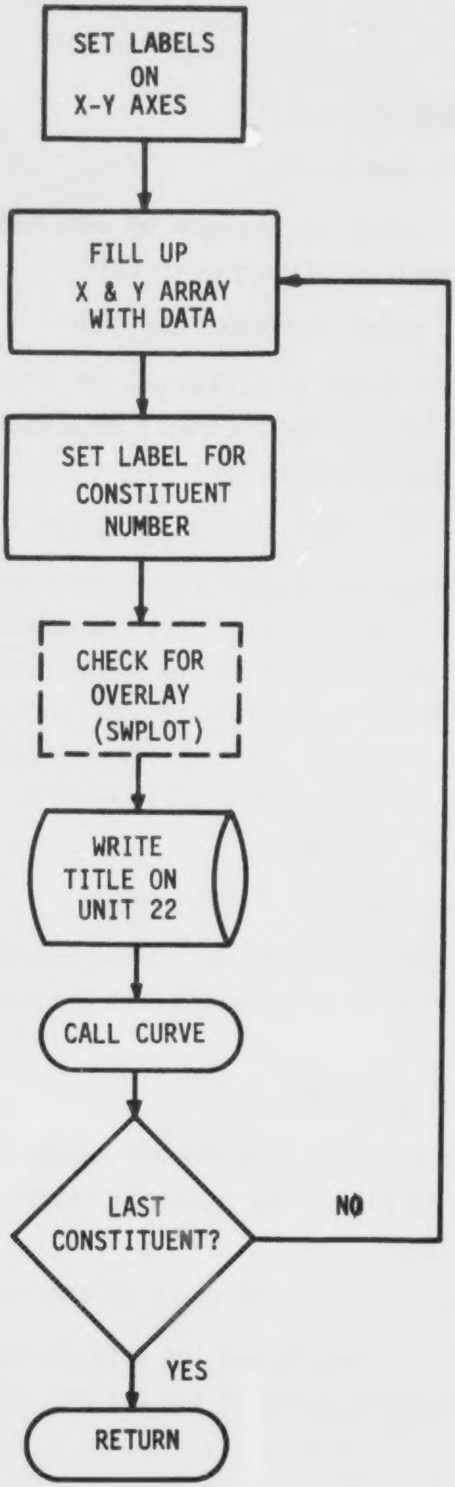

SET LABELS ON X-Y AXES
FILL UP X & Y ARRAY WITH DATA
SET LABEL FOR CONSTITUENT NUMBER
CHECK FOR OVERLAY (SWPLOT)
WRITE TITLE ON UNIT 22
CALL CURVE
LAST CONSTITUENT?
NO
YES
RETURN

FIGURE 3.8 FLOWCHART OF SUBROUTINES SUMPLT & SWPLOT

or "Constituent 2", etc.)

STEP 4 - WRITE OUT TITLE

A title indicating the type of plot and the cycle(s) to which it applies is written on Unit 22.

STEP 5 - CALL CURVE TO PRODUCE THE PLOT

Subroutine CURVE is called and the plot is produced on Unit 22. The printer plot will be outputted at the end of the MAIN computational loop.

3.6 SUBROUTINE TPLOT

This subroutine, called by the MAIN program, is linked to the generalized printer - plot subroutines (CURVE, PPLOT, and SCALE). It is called at the end of the MAIN program to produce time history plots at specified junctions for specified time periods. A simplified flowchart depicting the logic of TPLOT is shown in Figure 3.9. The sequence of steps is as follows:

STEP 1 - SET LABELS FOR X AND Y AXES

The labels (e.g. "cycles") for the x-axis *(BOTTOM(I))* and the labels (e.g. "Constituent") for the y-axis *(SIDE(I))* are set.

STEP 2 - TIME PLOT LOOP

This is a double loop which is executed for every constituent for every time plot. The following steps are executed within the loop.

STEP 2A - SKIP TO STARTING CYCLE OF TIME PLOT

Unit 11 is rewound and the data stored on it is read until the starting cycle of the current time plot is reached.

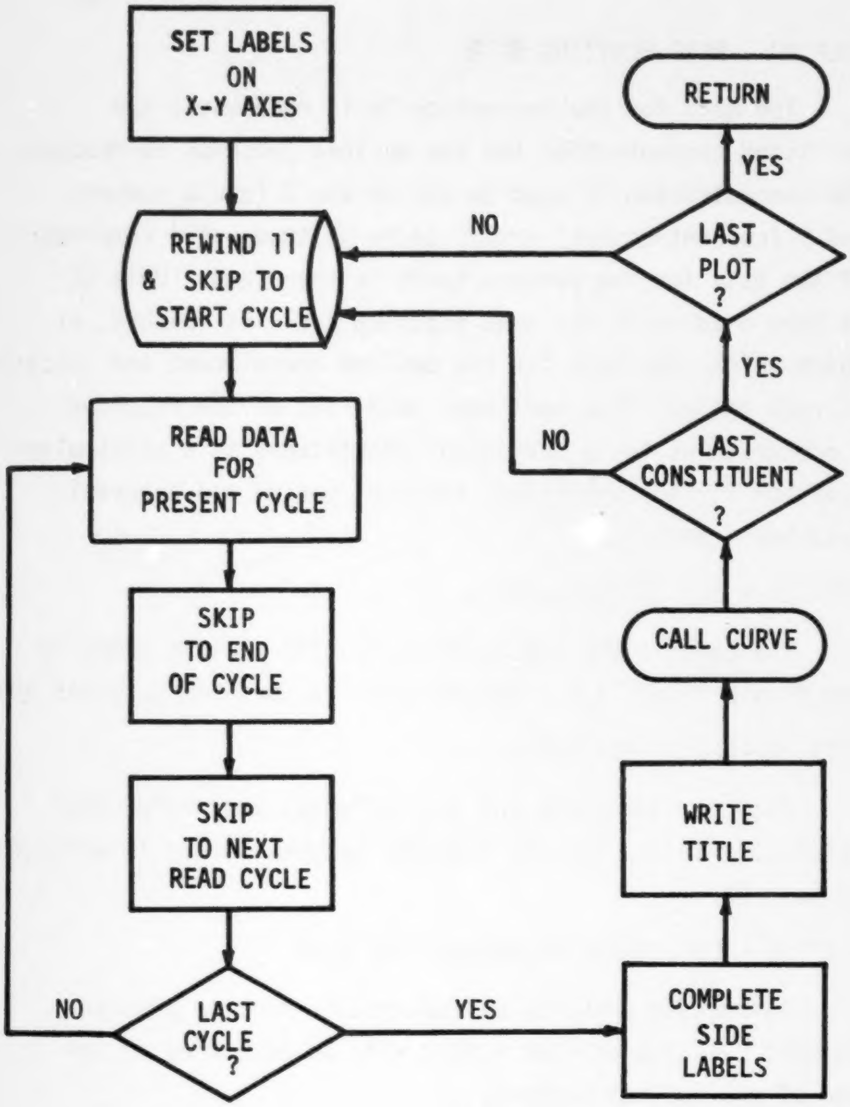

SET LABELS ON X-Y AXES
REWIND 11 & SKIP TO START CYCLE
READ DATA FOR PRESENT CYCLE
SKIP TO END OF CYCLE
SKIP TO NEXT READ CYCLE
LAST CYCLE ?
NO
YES
COMPLETE SIDE LABELS
WRITE TITLE
CALL CURVE
LAST CONSTITUENT ?
NO
YES
LAST PLOT ?
NO
YES
RETURN

FIGURE 3.9 FLOWCHART OF SUBROUTINE TPLOT

STEP 2B - READ PLOTTING DATA

The data for the present cycle is read until the predicted concentration for the desired junction is reached. The concentration is used to set up the X (cycle number) and Y (concentrations) arrays to be plotted. The remainder of the data for the present cycle is then read. Unit 11 is then read until the next plotting cycle is reached, at which point, the data for the desired constituent and junction is read again. This continues until all of the required concentrations for a particular constituent at a particular junction for the specified time plot period and interval have been read.

STEP 2C - SET UP SIDE LABELS

The constituent number for each time plot is added to the y-axis label (e.g. "Constituent" becomes "Constituent 2").

STEP 2D - WRITE OUT TITLE

A title indicating the type of plot, the cycles over which it applies, and the interval between points is written on Unit 22.

STEP 2E - CALL CURVE TO PRODUCE THE PLOT

Subroutine CURVE is called and the plot is produced on Unit 22. The printer - plot will be outputted at the end of the quality program.

3.7 PLOTTING SUBROUTINES - CURVE, PPLOT, SCALE

CURVE is the entry to a generalized printer - plot routine. It calls PPLOT and SCALE. CURVE plots the sequentially paired values in the X and Y arrays created in SUMPLT, SWPLOT, and TPLOT. The scaling values for both arrays are stored in the last two array locations (in the same manner as CALCOMP scaling).

Subroutine PPLOT produces the plots of the model predictions and observed data points.

Subroutine SCALE sets up convenient scales for the axes.

3.8 CONSTITUENT LINKAGES

The version of the DEM contained in this report has been applied to the Potomac Estuary. When this version was programmed, there were six quality constituents which were of particular interest:

Constituent 1 - Ammonia (NH_3)
Constituent 2 - Nitrate (NO_3)
Constituent 3 - Total Phosphorous (TPO_4)
Constituent 4 - Chlorophyll a (CHLOR)
Constituent 5 - Ultimate CBOD (CBOD)
Constituent 6 - Dissolved Oxygen (DO)

Consequently, many portions of the program and the constituent linkages are specific to those constituents. Figure 3.10 depicts the six constituents and the reaction rates which relate them in the quality program. The variables in capital letters are the reaction rates linking the constituents. The variables in italics are the masses transferred between constituents. The arrows indicate the direction of the transfer. At first glance, it might seem that this version of the model is very restrictive regarding the constituents that can be accomodated. However, closer examination reveals that there is a considerable degree of flexibility in assigning constituents to the constituent numbers utilized by the program. By manipulating the various rates associated with the constituent linkages, a fairly wide range of

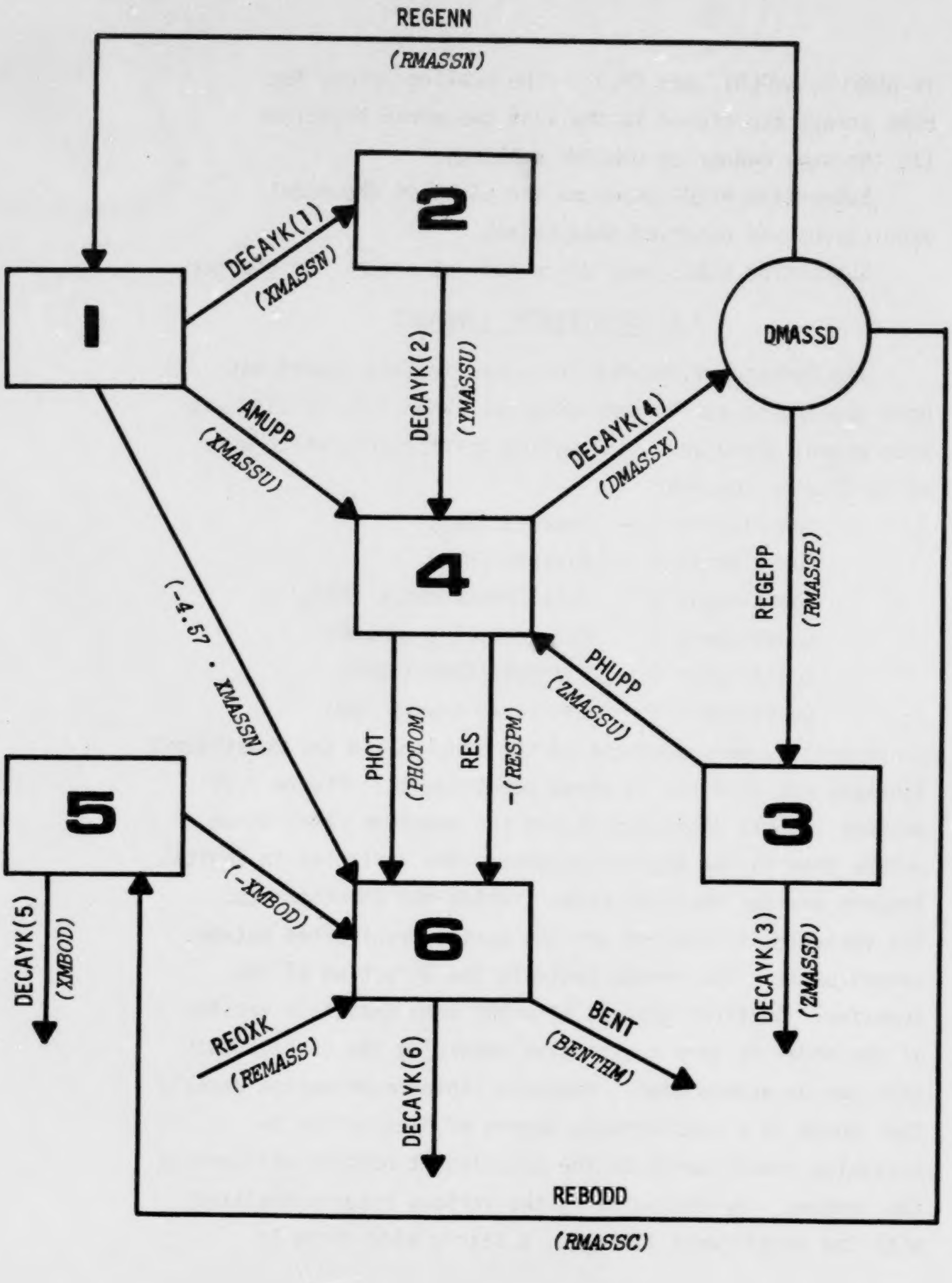

REGENN
(RMASSN)
1
2
DECAYK(1)
(XMASSN)
DECAYK(2)
(YMASSU)
DMASSD
AMUPP
(XMASSU)
DECAYK(4)
(DMASSX)
4
REGEPP
(RMASSP)
(-4.57 · XMASSN)
PHUPP
(ZMASSU)
PHOT
(PHOTOM)
RES
-(RESPM)
5
3
(-XMBOD)
6
DECAYK(5)
(XMBOD)
DECAYK(3)
(ZMASSD)
REOXK
(REMASS)
DECAYK(6)
BENT
(BENTHM)
REBODD
(RMASSC)

FIGURE 3.10 CONSTITUENT LINKAGES

parameters can be modeled. (A linkage can be "shut off" by setting the associated rate equal to zero). Examples of several alternative configurations are shown in Figures 3.11 to 3.13.

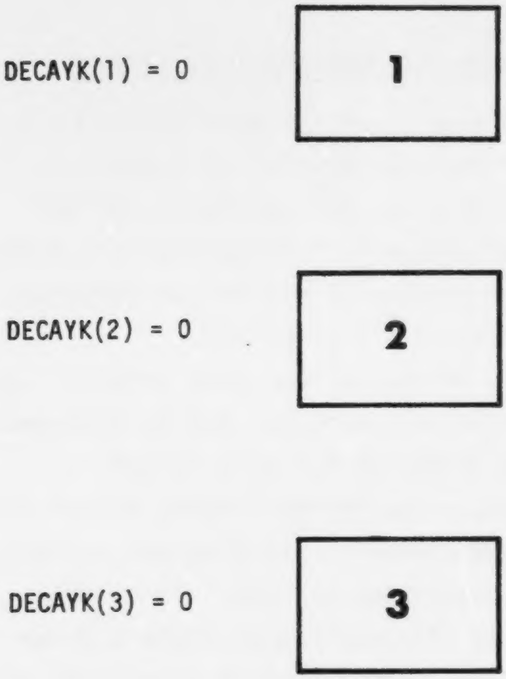
3.9 CONSIDERATIONS FOR MODELING OTHER SYSTEMS

There are several aspects of the model presented in this report which are characteristic of the estuary to which it was applied. However, the application of the DEM to other estuarine systems is a relatively straightforward process. The specific portions of the version contained herein which must be altered are as follows:

1) The Model Network - Obviously, the model network, i.e. the configuration of channels and junctions used to represent the prototype, will be different for every system.

2) DIMENSION Statements - The Potomac Estuary network consists of 133 junctions and 139 channels. Junction and channel parameters have been dimensioned to these values. Any expansion of the network size would necessitate a change in these dimensions. The Potomac model is programmed for 6 constituents. Therefore, all constituent related variables are dimensioned to that value. If more than 6 constituents are to be modeled, then those dimensions must be changed.

3) Plotting Positions - The plotting subroutines plot the predicted constituent concentrations for the model junctions. Each model junction that is plotted is referenced to the upper boundary of the network by variable *RMNODE(J)*, which specifies the number of miles between the upper boundary and junction J. Consequently, the values assigned to *RMNODE(J)* will have to be altered if a different network is used.

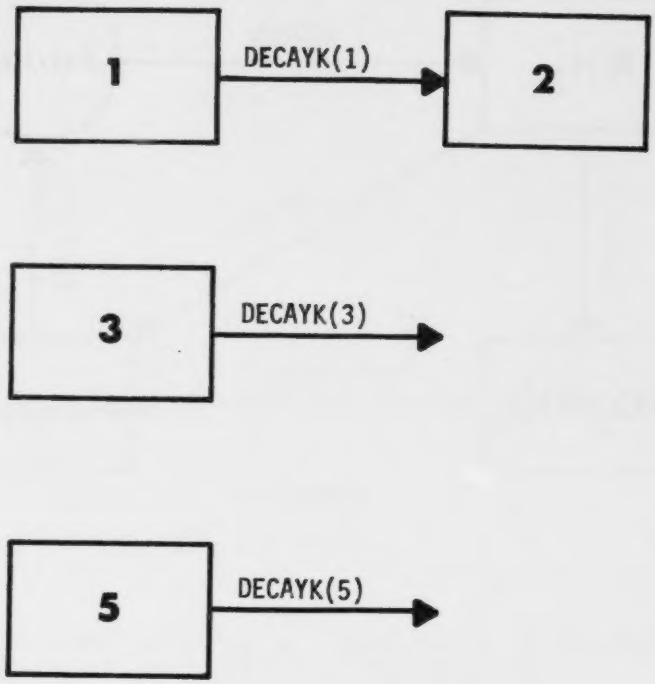

DECAYK(1) = 0
1
DECAYK(2) = 0
2
DECAYK(3) = 0
3

NUMCON = 3

KREAC = 3

Constituents 1, 2, and 3 are all
conservative, i.e. they do not decay

FIGURE 3.11 ALTERNATIVE LINKAGE EXAMPLE 1 - CONSERVATIVE CONSTITUENTS



NUMCON = 5

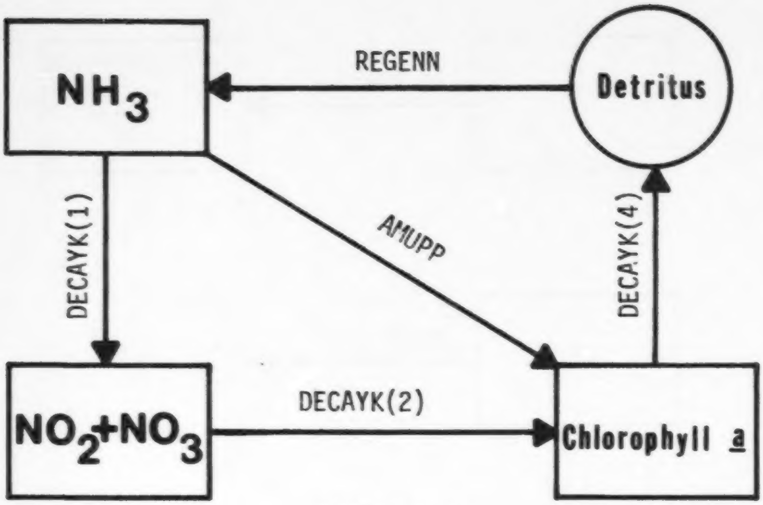
KREAC = 4

DECAYK(1) = the rate (1st order) at which constituent 1 is converted to constituent 2

DECAYK(3) = the rate (2nd order) at which constituent 3 is removed from the system

DECAYK(5) = the rate (1st order) at which constituent 5 is removed from the system

FIGURE 3.12 ALTERNATIVE LINKAGE EXAMPLE 2 - NON-CONSERVATIVE CONSTITUENTS


NH3
REGENN
Detritus
DECAYK(1)
AMUPP
DECAYK(4)
DECAYK(2)
NO2+NO3
Chlorophyll a

NUMCON = 4

KREAC = 1

DECAYK(1) = rate (1st order) at which NH_3 (constituent 1) is converted to NO_2+NO_3 (constituent 2)

DECAYK(2) = rate (1st order) at which NO_2+NO_3 is taken up by algae (constituent 4) for growth

DECAYK(4) = rate (1st order) at which algae are settled out of the system into the detrital pool

AMUPP = rate (1st order) at which NH_3 is taken up by algae for growth

REGENN = rate (1st order) at which NH_3 is regenerated by the detritus

FIGURE 3.13 ALTERNATIVE LINKAGE EXAMPLE 3 - THE NITROGEN CYCLE

4) Subroutine SWTABL - As discussed in section 3.4, this subroutine divides the network junctions into several groups. Each group is comprised of junctions which are at slack water at approximately the same time. These groups are characteristic of the system being modelled and will have to be changed for every different prototype.

3.10 INPUT REQUIREMENTS

The input requirements for this version of the DEM can be divided into five general categories: (1) input/output control parameters, (2) water quality parameters, (3) waste load inputs, (4) boundary conditions, and (5) initial conditions.

INPUT/OUTPUT CONTROL

The input/output control parameters can be divided into three groups: independent control, tabular output control, and graphical output control.

Independent control data specifies the number of quality constituents *(NUMCON)*, temperature *(TEMP)*, length of the run *(NQCYC)*, quality time step *(DELTQ)*, starting cycle on the hudraulic extract tape *(HYDCYC)*, and other parameters. A complete listing of these input parameters is given in Section 3.12.

Tabular output control specifies the types of tables to be outputted, the frequency of printout, and whether or not a plot of a table is desired. A complete listing of these parameters is found in Section 3.12.

Graphical output control specifies the number and type of plots, the type of background grid to use, the minimum *(YMINC(K))* and maximum*((YMAXC(K))* values which can be plotted, information concerning any observed data to be plotted, and which constituents to plot. A complete listing of these parameters is found in Section 3.12.

QUALITY PARAMETERS

Several reaction rates and coefficients must be specified for the quality constituents. These parameters determine the various linkages among the quality constituents. A complete listing of the parameters required for the version of the DEM in this report is found in Section 3.12.

WASTE LOAD PARAMETERS

For inflows to the system (e.g. wastewater discharges), both the flow and concentration of each constituent must be specified. For withdrawals from the system, only the flows need to be specified, since the concentration of each constituent removed is equal to the predicted concentration in that junction. If a bank load (runoff) input is used, the length of the junction shorelines *(SLINE(J))*, the flow, and the concentration of each constituent must be specified.

Normally, the hydraulic condition specified by the quality program should agree with the conditions in the hydraulic run. The reason for this is that the hydraulic behavior of the system for each quality time step is fixed in the hydraulic program and is not affected by the inflows or waste discharges specified in the quality program. Consequently, if a withdrawal existed in the hydraulic program, but was not specified in the quality program, then the quality program would have water removed from the junction, but not any constituent mass. Similarly, if a waste discharge is specified for a junction in the hydraulic program, then it is necessary to specify the constituent concentrations and the same flow rate in the quality program in order to add the appropriate mass of constituent during each time step. This feature makes it convenient to simulate the release of dye or some other tracer. Since a very small amount of tracer (with high concentration) is usually released into a junction, any convenient input flow rate and dye concentration can be specified (for the quality program alone) so that the appropriate mass of dye is added during each time step.

BOUNDARY CONDITIONS

Boundary conditions must be specified for the upper and lower junctions of the network. Frequently, one of the most troublesome inputs is the specification of the constituent concentrations at the seaward boundary. Ideally, the lower boundary would be the ocean (a source and sink with known concentration). The problem of specifying the boundary is one of estimating the tidal cycle variation in concentration of a constituent at a boundary for a given freshwater inflow to the system. For simulation of historic conditions, sufficient data should be collected to establish the boundary concentrations. For predictive runs, one must estimate the boundary conditions which would result for the run, i.e. the final results must be known in order to specify the boundary conditions. This dilemma can sometimes be circumvented by determining the sensitivity of upstream predictions to the location of the lower boundary. Since the effect of the lower boundary conditions on the upstream predictions decreases as the lower boundary is moved farther downstream, the boundary should be located well downstream from any areas of concern. For constituents with little or no concentration gradient, the boundary concentration can be specified as constant throughout the tidal cycle. For constituents with a significant gradient (e.g. salinity), the boundary condition is defined by specifying a concentration for each quality time step over a full tidal cycle.

INITIAL CONDITIONS

Initial concentrations must be specified for each constituent in every junction. For studies where steady state conditions are desired, the initial concentrations are relatively unimportant. However, while the initial conditions do not affect the final steady state concentrations, the execution time required to achieve a steady state condition can be extremely sensitive to the initial concentrations. For studies in which historical quality conditions are being simulated, the initial conditions are extremely inportant and adequate historical data should be available to define them.

3.11 OUTPUT OPTIONS

Both tabular and graphical output options are available in the version of the DEM presented in this report. Tabular outputs include summary tables, slack water tables, a dissolved oxygen summary, and a summary of nutrients limiting algal growth in each junction. Graphical outputs include plots of summary tables, plots of slack water tables, (with or without observed data), and time history plots at specified junctions.

TABULAR OUTPUTS

1) Summary Tables:

Summary tables are produced by subroutine SUMARY. A summary table prints the minimum, maximum, and average concentration for each constituent in every junction during a specified interval. In order to allow summaries which overlap, there are two types of tables referred to in SUMARY: a "Type 1" table and a "Type 2" table. A Type 1 table can overlap a Type 2 table (and vice versa). For example, a Type 1 table may summarize from cycle 100 to 150 and a Type 2 could summarize from cycle 100 to 250. There are *NSUM1* Type 1 tables and *NSUM2* Type 2 tables. The N^{th} Type 1 table begins its summary at cycle *IPRT1(N)* and ends its summary at cycle *LPRT1(N)*. If *IPLT1(N)* = 1, the N^{th} table will be plotted. Similarly, the N^{th} Type 2 table summarizes from cycle *IPRT2(N)* to cycle *LPRT2(N)* and will be plotted if *IPLT2(N)* = 1.

2) Slack Water Table:

Slack water tables are produced by subroutine SWTABL. These tables yield predictions for a junction when it is at slack water. The number of slack water tables equals *NSWTAB*. There are three types of slack water tables: high water slack (HWS), low water slack (LWS), and snapshot. (A snapshot table is not actually a slack water table as defined, rather, it gives the concentrations throughout the estuary at a specified cycle). The N^{th} slack water table begins at cycle *NFPC(N)*. The type of table is defined by *KSL(N)*, where *KSL(N)* = 0,1,2 indicates a snapshot, HWS table, or LWS table, respectively.

3) Dissolved Oxygen Summary:

A detailed summary of dissolved oxygen (constituent 6) predictions is obtained from cycle *NDOCYC* to the end of the quality run. The summary includes the minimum and maximum predicted D.O. concentrations for each junction *(DOMIN(J), DOMAX(J))* and the cycles at which they occur *(MINCYC(J), MAXCYC(J))*; the average predicted D.O. concentration for each junction *(AVGDO(J))*; and the number of cycles for which the predicted D.O. concentrations for each junctions were below 4.0 mg/l,*(DOLT4(J))*, between 4.0 mg/l and 5.0 mg/l *(DO4TO5(J))*, and greater than 5.0 mg/l *(DOGT5(J))*.

4) Nutrient Limitation Summary:

A summary of nutrient limitation is obtained from cycle *NUTCYC* to the end of the quality run. The summary identifies the number of cycles in which nitrogen limited algal growth *(NNRL(J))* and the number of cycles in which phosphorous limited algal growth *(NPRL(J))* in each junction.

GRAPHICAL OUTPUTS

1) Summary Plots:

The number of Type 1 tables plotted equals *NPLT1* and the number of Type 2 tables plotted equals *NPLT2*. If *IPLT1(N)* = 1, then the Nth Type 1 table will be plotted. If *IPLT2(N)* = 1, then the Nth Type 2 table will be plotted.

The plotting symbols are defined as follows: "H", "L", and "A" correspond to the maximum, minimum, and average concentrations, respectively. Summary plots do not contain observed data points.

2) Slack Water Plots:

The variable *KPLOT(N)* defines the type of slack water plot, if any, to be generated. *KPLOT(N)* = 0,1,3,4 indicates that the Nth slack water table will: not be plotted, be plotted, be prepared for an overlay of constituent 6 (i.e. prepare to plot constituent 6 from the next (N + 1th) slack water table and Nth slack water table together), or perform the overlay of constituent 6. If *NCONSW(K)* = 0, then constituent K will not be plotted in any slack water table.

Observed data, read in through the card reader with the data deck, can also be plotted on a slack water plot (along with the model predictions). Observed data is read *NOBDAT* times. It is read in at specified quality cycles *(OBCYC(I)*, I = 1,*NOBDAT)*. Each block of observed data contains *NDATA* points. The location of each point is defined by *RMDATA(K)*, where K = 1,*NDATA*. The plotting symbols are defined as follows: a "*" corresponds to a slackwater point; an "X" corresponds to an overlayed slack water point; and "H", "L", and "A" correspond to the three observed data points (either high, low, average or day 1, day 2, or day 3).

3) Time History Plots:

There are *NTP* time history plots. The N^{th} time history plot is specified for junction *JUNCTP(N)*. It begins at cycle *NSCTP(N)*, ends at cycle *NECTP(N)*, and plots data at intervals of *NCITP(N)* cycles. If *NCONTP(N,K)* = 0, then the N^{th} time plot will not inclued constituent K.

3.12 DYNQUAL DATA DECK SEQUENCE

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
1	ALPHA(J)	1-80	20A4	2 cards. Identifies the run.
2	NJ	1-5	I5	
	NC	6-10	I5	
	NSTART	11-15	I5	
	NSTOP	16-20	I5	
	NODYN	21-25	I5	
3	HEADER	1-80	20A4	Indicates Control Data is to be read.
4	HYDCYC	1-5	I5	
	NQCYC	6-10	I5	
	NUTCYC	11-15	I5	
	NDOCYC	16-20	I5	
	NSPEC	21-25	I5	
5	NUMCON	1-5	I5	
	KDCOP	6-10	I5	
	KREAC	11-15	I5	
	MIX	16-20	I5	
6	TEMP	1-10	F10.0	
	STIME	11-20	F10.0	
7	HEADER	1-80	20A4	Indicates Tabular Output Control is to be read.

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
8	NSUM1	1-5	I5	
	NPLT1	6-10	I5	
9	IPRT1(N)	1-5	I5	Read NSUM1 of these cards.
	LPRT1(N)	6-10	I5	
	IPLT1(N)	11-15	I5	
10	NSUM2	1-5	I5	
	NPLT2	6-10	I5	
11	IPRT2(N)	1-5	I5	Read NSUM2 of these cards.
	LPRT2(N)	6-10	I5	
	IPLT2(N)	11-15	I5	
12	NSWTAB	1-5	I5	
13	NFPC(N)	1-5	I5	Read NSWTAB of these cards.
	KSL(N)	6-10	I5	
	KPLOT(N)	11-15	I5	
14	HEADER	1-80	20A4	Indicates Plotting Output Control is to be read.
15	NTP	1-5	I5	
	NSWP	6-10	I5	
	KPLOP	11-15	I5	

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
16	NDATA	1-5	I5	
	NOBDAT	6-10	I5	
17*	NOBCYC(1)	1-5	I5	* Read only if NOBDAT>0.
	NOBCYC(2)	6-10	I5	Read NOBDAT valves of
	.	.	.	NOBCYC.
	.	.	.	
	.	.	.	
18	NCONSW(1)	1-5	I5	Read NUMCON values of NCONSW.
	NCONSW(2)	6-10	I5	
	.	.	.	
	.	.	.	
	.	.	.	
19	JUNCTP(N)	1-5	I5	Read NTP of these cards.
	NSCTP(N)	6-10	I5	Read NUMCON values of NCONTP
	NECTP(N)	11-15	I5	on each card.
	NCITP(N)	16-20	I5	
	NCONTP(N,1)	21-35	I5	
	NCONTP(N,2)	26-30	I5	
	.	.	.	
	.	.	.	
	.	.	.	

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
20	YMAXC(1)	1-5	F5.0	Read NUMCOM values of YMAXC and YMINC.
	YMINC(1)	6-10	F5.0	
	YMAXC(2)	11-15	F5.0	
	YMINC(2)	16-20	F5.0	
	.	.	.	
	.	.	.	
	.	.	.	
21	HEADER	1-80	20A4	Indicates Quality Coefficients are to be read.
22	PERCD	1-10	F10.0	
	CHLNIT	11-20	F10.0	
	CHLPHO	21-30	F10.0	
	CHLCAR	21-40	F10.0	
23	BACKC(K)	1-10	F10.0	Read NUMCON of these cards.
	THETA(K)	11-20	F10.0	
	CLIMIT(K)	21-30	F10.0	
	CNAME(N)	31-39	2A4	
24	HEADER	1-80	20A4	Indicates D.O. Parameters are to be read.
25	TSRISE	1-10	F10.0	
	TSSET	11-20	F10.0	
26	NO	1-5	I5	

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
27	NF1(I)	1-10	I10	Read NO of these cards.
	NL1(I)	11-20	I10	
	PHOT(I)	21-30	F10.0	
	RES(I)	31-40	F10.0	
	DEPTH(I)	41-50	F10.0	
	BENT(I)	51-60	F10.0	
28	IREOXK	1-5	I5	
29*	REOXK	1-10	F10.0	*Read only if IREOXK = 4
30	HEADER	1-20	20A4	Indicates Diffusion Constants are to be read.
31	NK	1-5	I5	
32	NFC(I)	1-10	I10	Read NK of these cards.
	NLC(I)	11-20	I10	
	CDIFFK(J)	21-30	F10.0	
33	HEADER	1-80	20A4	Indicates Nutrient Uptake and Regeneration rates are to be read.
34	NR	1-5	I5	

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
35	NF2(I)	1-10	I10	Read NR of these cards.
	NL2(I)	11-20	I10	
	AMUPP(I)	21-30	F10.0	
	PHUPP(I)	31-40	F10.0	
	REGENN(I)	41-50	F10.0	
	REGEPP(I)	51-60	F10.1	
	REBODD(I)	61-70	F10.0	
36	HEADER	1-80	20A4	Indicates Decay Rates are to be read.
37	ND	1-5	I5	
38	NF3(I)	1-10	I10	Read ND of these cards. Read NUMCON values of DECAYK on each card.
	NL3(I)	11-20	I10	
	DECAYK(I,1)	21-30	F10.0	
	DECAYK(I,2)	31-40	F10.0	
	.	.	.	
	.	.	.	
	.	.	.	
39	HEADER	1-80	20A4	Indicates Wastewater Inputs are to be read.
40	NWASTC	1-5	I5	
	NWASTV	6-10	I5	
	NBANK	11-15	I5	
41	HEADER	1-80	20A4	Indicates Constant Inputs are to be read.

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
42	JRCW(I)	1-10	I10	Read NWASTC of these cards.
	QCW(I)	11-20	F10.0	
	CWC(I,1)	21-30	F10.0	
	CWC(I,2)	31-40	F10.0	
	.	.	.	
	.	.	.	
	.	.	.	
43	HEADER	1-80	20A4	Indicates Variable Inputs are to be read.
44a	JRVW(I)	1-10	I10	Read NWASTV of the 44a cards. Every 44a card is followed by NINC(I) of the 44b cards.
	NINC(I)	11-20	I10	
44b	INCDUR(I,N)	1-10	I10	
	FLO(I,N)	11-20	F10.0	
	CON(1,I,N)	21-30	F10.0	
	CON(2,I,N)	31-40	F10.0	
	.	.	.	
	.	.	.	
	.	.	.	
45	HEADER	1-80	20A4	Indicates Variable Bank Inputs are to be read.
46	SLINE(1)	1-5	F5.0	Repeat card 46 until NJ valves of SLINE have been read.
	SLINE(2)	6-10		
	.	.	.	
	.	.	.	
	.	.	.	

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
47a	JRBL1(I)	1-5	I5	Read NBANK of the 47a cards. Every 47a card is followed by one 47b card.
	JRBL2(I)	6-10	I5	
	ICYC1(I)	11-15	I5	
	ICYC2(I)	16-20	I5	
47b	BFLOW	1-10	F10.0	
	BCON(I,1)	11-20	F10.0	
	BCON(I,2)	21-30	F10.0	
	.	.	.	
	.	.	.	
	.	.	.	
48	HEADER	1-80	20A4	Indicates Upper Boundary Conditions to be read.
49	NINC(I)	1-5	I5	I = NWASTV + 1.
50	INCDUR(I,N)	1-10	I10	Read NINC(I) of these cards, where I = NWASTV + 1.
	FLO(I,N)	11-20	F10.0	
	CON(1,I,N)	21-30	F10.0	
	CON(2,I,N)	31-40	F10.0	
	.	.	.	
	.	.	.	
	.	.	.	
51	HEADER	1-80	20A4	Indicates Initial Conditions are to be read.

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
52	JINT1	1-10		Read until JINT2 equals NJ. Read NUMCON values for CINT on each card.
	JINT2	11-20		
	CINT(1)	21-30		
	CINT(2)	31-40		
	.	.	.	
	.	.	.	
	.	.	.	
53	HEADER	1-80	20A4	Indicates Seaward Boundary Conditions are to be read.
54	SEACON(1)	1-5	I5	Read NUMCON values for SEACON.
	SEACON(2)	6-10	I5	
	.	.	.	
	.	.	.	
	.	.	.	
55a	CIN(K,1)	1-5	F5.0	Read this card if SEACON(K) = 1
55b	CIN(K,1)	1-5	F5.0	Read this card if SEACON(K) = 2 Read NSPEC values of CIN on each card.
	CIN(K,2)	6-10	F5.0	
	CIN(K,3)	11-15	F5.0	
	.	.	.	
	.	.	.	
	.	.	.	
56	HEADER	1-80	20A4	Read if observed data is to be read during the current cycle.

CARD	VARIABLE	COLUMNS	FORMAT	COMMENTS
57	OBDATA(1,1,K)	1-4	F4.0	Read if observed data is to be read during the current cycle. Read NDATA of these cards
	OBDATA(2,1,K)	5-8	F4.0	
	OBDATA(3,1,K)	9-12	F4.0	
	OBDATA(1,2,K)	13-16	F4.0	
	OBDATA(2,2,K)	17-20	F4.0	
	.	.	.	
	.	.	.	
	.	.	.	
	OBDATA(2,6,K)	65-68	F4.0	
	OBDATA(3,6,K)	69-72	F4.0	
	OBDATA(K)	73-80	F8.0	

3.13 DYNQUAL VARIABLE DEFINITIONS

The following pages contain definitions of the major variables in DYNQUAL. Variables are listed in alphabetical order. Variables in italics are read from the input data deck.

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
ADMASS	MIXER	Mass of constituent transferred by advection between the junctions at each end of a channel.		lbs
ALPHA(I)	MAIN	Alphanumeric identifier, serves as heading for output.		
AMUP(J)	MAIN	Ammonia uptake rate by algae in junction J.		
AMUPP(I)	MAIN	Uniform ammonia uptake rate by algae for junction group I. (I = 1,NR)		
AREA(N)	MAIN MIXER	Cross sectional area of channel N. Must correspond to heads specified at ends of channel.		ft^2
ASUR(J)	MAIN	Surface area of junction J.		ft^2
AVGD	MAIN	Average depth of junction.		ft
AVOL(J)	MAIN	Average volume of junction J.		ft^3
B(N)	MAIN	Width of channel N.		ft
BACKC(K)	MAIN	Background concentration of constituent K.		
BCON(I,K)	MAIN	Concentration of constituent K in bank load I.		
BENT(I)	MAIN	Uniform benthic demand rate of junction group I. (I = 1,NO)		
BENTH(J)	MAIN	Benthic demand rate of junction J.		
BENTHM	MAIN	Mass of oxygen in a junction depleted by benthic demand during a quality time step.		
BFLOW	MAIN	Bank flow.		cfs

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
C(J,K)	MAIN MIXER SUMARY SWTABL	Concentration of constituent K in junction J.		mg/l
CA	MIXER	Concentration in junction NJUNC(NL,K).		mg/l
CARCHL	MAIN	1./CHLCAR. Ratio of carbon to chlorophyll in algae.		mg/µg
CAVG1(J,K)	SUMARY	Average concentration of constituent K in junction J for a Type I summary.		mg/l
CAVG2(J,K)	SUMARY	Average concentration of constituent K in junction J for a Type 2 summary.		mg/l
CB	MIXER	Concentration in junction NJUNC(NH,K).		mg/l
CDIFFK(I)	MAIN	Diffusion constant for group I, used for computing channel diffusion coefficients. (I = 1,NK).		
CHLCAR	MAIN	Ratio of chlorophyll to carbon, in algae.		µg/mg
CHLNIT	MAIN	Ratio of chlorophyll to nitrogen in algae.		µg/mg
CHLPHO	MAIN	Ratio of chlorophyll to phosphorus in algae.		µg/mg
CIN(K,I)	MAIN	Seaward boundary concentration of constituent K for time step I during a tidal cycle. (I = 1,NSPEC).		
CINT(K)	MAIN	Initial concentration of constituent K. (K = 1,NUMCON)		
CLEN(N)	MIXER	Length of channel N.		ft

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
CLIMIT(K)	MAIN	Concentration limit for constituent K. Execution is terminated if the predicted concentration for constituent K exceeds CLIMIT(K).		mg/1
CMASS(J,K)	MAIN MIXER	Mass of constituent K in junction J.		lbs
CMAX1(J,K)	SUMARY	Maximum concentration of constituent K in junction J for a Type 1 summary.		mg/1
CMAX2(J,K)	SUMARY	Maximum concentration of constituent K in junction J for a Type 2 summary.		mg/1
CMIN1(J,K)	SUMARY	Minimum concentration of constituent K in junction J for a Type 1 summary.		mg/1
CMIN2(J,K)	SUMARY	Minimum concentration of constituent K in junction J for a Type 2 summary.		mg/1
CN(N)	MAIN	Manning roughness coefficient of channel N.		
CNAME(N)	MAIN	Alphanumeric variable indicating the constituent name.		
CON(K,I,N)	MAIN	Concentration of constituent K, from variable waste input I (variable discharger or upper boundary) during time increment N.		mg/1
CONC	MIXER	Concentration in advected water.		mg/1
CONCW(J,K)	MAIN	Concentration of constituent K entering junction J from all constant waste inputs into junction J. Computed by dividing the total load entering the junction by the total input flow.		mg/1
CSAT	MAIN	Dissolved oxygen saturation concentration.		

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
CTIME	MAIN SWTABL	Clock time of the run. Equals tne time of day, taken with respect to the time of day (STIME) that the run began.		
CWC(I,K)	MAIN	Concentration of constituent K for constant waste input I.		
CWLOAD	MAIN	Constant waste load of constituent K into junction J.		
DECAY(J,K)	MAIN	Decay rate of constituent K in junction J.		
DECAYK(I,K)	MAIN	Decay rate of constituent K in group I. (I = 1,ND)		
DELT	MAIN	Time interval in the hydraulic program.		sec
DELTQ	MIXER SWTABL SUMARY	Time step for the quality program. (DELTO = DELT * NODYN).		sec
DELTQ1	MAIN	Quality time step (DELTQ1 = DELT * NODYN/3600.)		hrs
DEPTH(I)	MAIN	Uniform photic depth of junction group I. (I = 1,NO)		ft
DEPTHP(J)	MAIN	Photic depth of junction J.		ft
DIFFC	MIXER	Diffusion coefficient for a channel during a quality time step. Equals DIFFK(N) * R(N) * Q(N)		
DIFFK(N)	MAIN MIXER	Diffusion coefficient in channel N.		
DIMASS	MIXER	Mass of constituent transferred by diffusion between the junctions at each end of a channel.		lbs
DIMASSD(J)	MAIN	Amount of biodegradable material in detrital pool for junction J.		

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
DMASSX	MAIN	Amount of chlorophyll decayed into a junction's detrial pool during a quality time step.	R	
DOAVG(J)	MAIN	Average DO in junction J (beyond cycle NDOCYC).	R	mg/l
DOLT4(J)	MAIN	Number of cycles (beyond cycle NDOCYC) in which the predicted DO in junction J is less than 4 mg/l.		
DO4TO5(J)	MAIN	Number of cycles (beyond cycle NDOCYC) in which the predicted DO in junction J is between 4mg/l and 5 mg/l.	R	mg/l
DOGT5(J)	MAIN	Number of cycles (beyond cycle NDOCYC) in which the predicted DO in junction J is greater than 5 mg/l.	R	mg/l
DOMAX(J)	MAIN	Maximum DO for junction J (beyond cycle NDOCYC).	R	mg/l
DOMIN(J)	MAIN	Minimum DO for junction J (beyond cycle NDOCYC).	R	mg/l
DTD	MAIN	Quality time step. (Equals DELTQ1/24.)	R	days
FGQXA(NPP)	SUMARY SUMPLT	Array created to store the abscissa (x-axis) values of the points to be plotted.	R	
FGQXO(I, LPP,NPP)	SUMARY SUMPLT	Array created to store the ordinate (y-axis) values of the points to be plotted. I = 1 corresponds to the maximum concentration I = 2 corresponds to the average concentration I = 3 corresponds to the minimum concentration LPP = 1 corresponds to constituent 1 LPP = 2 corresponds to constituent 2 LPP = 3 corresponds to constituent 3 LPP = 4 corresponds to constituent 4 LPP = 5 corresponds to constituent 5 LPP = 6 corresponds to constituent 6	R	
FGSWA(NPP)	SWTABL SWPLOT	Array created to store the abscissa (x-axis) alues of the points to be plotted.	R	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
FGSWO(NPP, LPP)	SWTABL SWPLOT	Array created to store the ordinate(y-axis) values of the points to be plotted. NPP indicates which point. LPP indicates which constituent, i.e. LPP=1 for constituent 1, LPP=2 for constituent 2, etc.	R	
FLO(I,N)	MAIN	Waste flow of variable discharge I (variable or upper boundary) during during time increment I.	R	cfs
HEADER	MAIN	Alphanumeric identifier for a subsection of the input card deck.	R	
HOURS	SWTABL	Clock time, i.e. the time of day, taken with respect to the time at which the quality run began (STIME).		
HOURS1	SUMARY	Number of hours between KDAYS1 and the first cycle (IP) of the summary table.	R	
HOURS2	SUMARY	Number of hours between KDAYS2 and the last cycle (LP) of the summary summary table.	R	
HYDCYC	MAIN	Hydraulic cycle number at which the quality run is to start.	I	
ICYC	MAIN SWTABL SUMARY	Cycle number (iteration) during execution of the quality program.	I	
ICYC1(I)	MAIN	Starting cycle for the I^{th} bank load input.	I	
ICYC2(I)	MAIN	Ending cycle for the I^{th} bank load input.	I	
ICYCTF	MAIN	Cycle number from the hydraulic (transient flow) program which is stored on unit 4 (hydraulic extract tape).	I	
ILARGE	MAIN	Flag used in determining which of the channels entering a junction has the highest flow.		
INCDUR(I,N)	MAIN	Duration of the N^{th} time increment for variable waste discharge I. (N=ININC(I)).	I	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
IP	SUMARY	First cycle of the summary table.	I	
IPLT1(N)	MAIN	Type 1 Summary plotting control. IPLT1(N) = 0 Nth Type 1 Summary Table is not plotted. 1 Nth Type 1 Summary Table is plotted.	I	
IPLT2(N)	MAIN	Type 2 Summary plotting control. IPLT2(N) = 0 the N^{th} Type 2 summary table is not plotted. 1 the N^{th} Type 2 summary table is plotted.	I	
IPRT1(N)	MAIN	Initial print cycle for the N^{th} Type 1 Summary table.	I	
IPRT2(N)	MAIN	Initial print cycle for the N^{th} Type 2 Summary table.	I	
IREOXK	MAIN	Control option for choosing method of determining reoxygenation rate. IREOXK = 1 O'Connor-Dobbins equation used to compute reoxygenation rate. 2 Churchill equation used to compute reoxygenation rate. 3 USGS equation used to compute reoxygenation rate. 4 Reoxygenation rate is constant and equal to REOXK.	I	
ITAB	MAIN SWATBL	Counter to determine which portion of a slack water table is to be printed.	I	
JINT1	MAIN	The first junction in an initial condition group.	I	
JINT2	MAIN	The last junction in an initial condition group.	I	
JPRT(I,J)	SWTABL	Junction number of the J^{th} junction in the I^{th} slack water group (J = 1,NOPRT(I)).	I	
JRBL1(I)	MAIN	First junction receiving bank load I.	I	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
JRBL2(I)	MAIN	Last junction receiving bank load I.	I	
JRCW(I)	MAIN	Junction receiving the I^{th} constant waste input.	I	
JRVW(I)	MAIN	Junction receiving the I^{th} variable waste input.	I	
JUNCTP(N)	MAIN	Junction specified for the N^{th} time plot. Time plots can be specified for any junction.	I	
KCYC(I)	MAIN	Counter used to determine when the end of a variable waste time increment is reached.	I	
KDAYS	SWTABL	Number of full days which have elapsed since the beginning (STIME) of the quality run.	I	
KDAYS1	SUMARY	Number of full days from beginning of quality run to the first cycle (IP) of the summary table.	I	
KDAYS2	SUMARY	Number of full days from beginning of quality run to the last cycle (LP) of the summary table.		
KDCOP	MAIN	Control option. Determines whether or not depletion corrections are printed. KDCOP = 0 depletion corrections not printed. 1 depletion corrections printed.	I	
KINC(I)	MAIN	Counter used to determine which variable waste increment is being used.	I	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
KPLOP	MAIN	Control option determining plotting background grids. KPLOP = 0 no background grid produced. 1 low density background grid. 2 medium density background grid. 3 high density background grid.	I	
KPLOT(N)	MAIN SWTABL	Control parameter for plots of the N^{th} slack water table. KPLOT(N) = 1 no plots will be printed. 2 plots will be printed. 3 prepone overlay for constituent 6 4 overlay for consituent 6 performed.	I	
KREAC	MAIN	Control option for consitutent linkages. KREAC = 1 only nitrogen uptake be algae is considered (i.e., constituent 3 is not simulated). 2 only phosphorus uptake by algae is considered (i.e., constituents 1 and 2 are not simulated). 3 both nitrogen and phosphorus uptake by algae are considered. 4 algae (constituent 4) is not simulated.	I	
KSL(N)	MAIN SWTABL	Control option defining the N^{th} slack water table. KSL(N) = 0 snapshot table is desired. 1 high water slack table desired. 3 low water slack table desired.	I	
LP	SUMARY	Last cycle of the summary table.	I	
LPRT1(N)	MAIN	Last print cycle for the N^{th} Type 1 Summary table.	I	
LPRT2(N)	MAIN	Last print cycle for the N^{th} Type 2 Summary table.	I	
MAXCYC(J)	MAIN	Cycle at which the maximum DO for junction J occurs (beyond cycle NDOCYC).	I	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
MCHLON	MAIN	Maximum amount of constituent 4 (chlorophyll) which can be produced from the total inorganic nitrogen (XMASSU + YMASSU) taken up during a quality time step.	R	
MCHLOP	MAIN	Maximum amount of constituent 4 (chlorophyll) which can be produced from the phosphorus taken up (ZMASSU) during a quality time step.	R	
MINCYC(J)	MAIN	Cycle at which the minimum D.O. for junction J occurs (beyond cycle NDOCYC).	I	
MIX	MAIN MIXER	Variable which defines the method used to compute the concentration in advected water. 1 use upstream concentration. 2 use 1/2 point concentration. MIX = 3 use 1/3 point concentration. 4 use 1/4 point concentration. 5 use 2-way proportional concentration.	I	
MTABL	MAIN SWTABL	Counter to determine which slack water table is to be printed.	I	
NBANK	MAIN	Number of bank load inputs.	I	
NC	MAIN MIXER	Number of channels in network.	I	
NCHAN(J,K)	MAIN	Channel number of the K^{th} channel entering junction J (K = 1.5).	I	
NCITP(N)	MAIN	Interval between data points on the N^{th} time plot. (e.g. if NCITP(2) = 25, then the 2^{nd} time plot will plot a data point every 25 cycles).	I	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
NCONSW(K)	MAIN SWTABL	Control parameter for slack water plots. NCONSW(K) = 0 constituent K is not plotted on slack water plots. 1 constituent K is plotted on slack water plots.	I	
NCONTP(N,K)	MAIN TPLOT	Control parameter for time plots. NCONTP(N,K) = 0 constituent K for time plot N is not plotted. 1 constituent K for time plot N is plotted.	I	
ND	MAIN	Number of groups of junctions having uniform constituent decay rate (DECAYK(K)).	I	
NDA	MAIN	Counter to determine which group of observed data is being read.	I	
NDATA	MAIN	Number of observed data points contained in each group of observed data, i.e. the number of locations for which there is observed data.	I	
NDOCYC	MAIN	Cycle at which summary of constituent 6 (D.O.) begins.	I	
NECTP(N)	MAIN	Ending cycle for the N^{th} time plot.	I	
NFC(I)		Number of the first channel of the I^{th} group of channels with a uniform diffusion constant (I = 1,NK).		
NF1(I)	MAIN	Number of the first junction of the I^{th} group of junctions with uniform D.O. (constituent 6) related coefficients (I = 1,NO).	I	
NF2(I)	MAIN	Number of the first junction of the I^{th} group of junctions with uniform Uptake and Reg	I	
NF3(I)	MAIN	Number of the first junction of the I^{th} group of junctions with uniform Decay Rates (I = 1,ND).	I	
NFPC(M)	MAIN SWTABL	Number of the first printout cycle for the N^{th} slack water table.	I	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
NINC(I)	MAIN	Number of time intervals describing the varying flows and/or conc concentrations for a time varying waste input (variable discharge or upper boundary).	I	
NITCHL	MAIN	1./CHLNIT. Ratio of nitrogen to chlorophyll in algae.	R	
NJ	MAIN SUMARY	Number of junctions in model network.	I	
NJUNC(N,1)	MAIN MIXER	Lower of the two junction numbers at the ends of channel N.	I	
NJUNC(N,2)	MAIN MIXER	Higher of the two junction numbers at the ends of channel N.	I	
NK	MAIN	Number of groups of channels having uniform diffusion constants (CDIFFK(I)).	I	
NL1(I)	MAIN	Number of the last junctions of the I^{th} group of junctions with uniform D.O. (constituent 6) related coefficients.	I	
NL2(I)	MAIN	Number of the last junction of the I^{th} group of junctions with uniform uptake and regeneration rates (I = 1,NR).	I	
NL3(I)	MAIN	Number of the last junction of the I^{th} group of junctions with uniform decay rates (I = 1,ND).	I	
NLC(I)	MAIN	Number of the last channel of the I^{th} group of channels with a niform diffusion constant (I = 1,NK).	I	
NLPC(M)	MAIN SWTABL	Last cycle of the M^{th} slack water table. Equals NFPC(M) + NSWCYC.	I	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
NNRL(J)	MAIN	Number of cycles in which nitrogen limits the growth of algae in junction J.	I	
NO	MAIN	Number of groups of junctions having uniform D.O. related coefficient coefficients (PHOT, RES, DEPTH, BENT).	I	
NOBCYC(I)	MAIN	Cycle at which the I^{th} group of observed data is read (I = 1,NOBDAT).	I	
NOBDAT	MAIN	Number of groups of observed data.	I	
NODYN	MAIN	Number of hydraulic time steps per quality time step.	I	
NOPRT(I)	MAIN	Number of junctions in the I^{th} slack water group.	I	
NPLT1	MAIN	Number of plots of Type 1 Summary tables.	I	
NPLT2	MAIN	Number of plots of Type 2 Summary tables.	I	
NPP	SUMARY SWTABL	Number of points plotted.	I	
NPRL(J)	MAIN	Number of cycles where phosphorus limits the growth of algae in junction J.	I	
NQCYC	MAIN	Number of quality time steps to be executed.	I	
NR	MAIN	Number of groups of junctions having uniform nutrient uptake and regneration rates. (AMUPP, PHUPP, REGENN, REGEPP, REBODD).	I	
NS1	MAIN	Counter to determine which Type 1 Summary table is being outputted.	I	
NS2	MAIN	Counter to determine which Type 2 Summary table is being outputted.	I	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
NSCTP(N)	MAIN	Starting cycle for the N^{th} time plot.	I	
NSPEC	MAIN	Number of quality cycles per tidal period.	I	
NSTART	MAIN	Starting cycle on the hydraulic extract tape (Unit 4).	I	
NSTOP	MAIN	Ending cycle on the hydraulic extract tape (Unit 4).	I	
NSUM1	MAIN	Number of Type 1 Summary tables to be printed.	I	
NSUM2	MAIN	Number of Type 2 Summary tables to be printed.	I	
NSWCYC	MAIN SWTABL	Number of quality cycles required for slack water to reach the upper boundary from the lower boundary.	I	
NSWP	MAIN SWTABL	Number of slack water plots.	I	
NSWTAB	MAIN	Number of slack water tables.	I	
NTAG	MAIN	Counter which is reset to zero at the completion of each full tidal cycle. NTAG varies between zero and NSPEC, where NSPEC is the number of quality cycles per tidal cycle.	I	
NTEMP	MAIN	Number which marks the end of the hydraulic record and signals a rewind command.	I	
NTP	MAIN	Number of time plots.	I	
NUM	SUMARY	Variable which determines if a Type 1 or a Type 2 summary is desired. NUM = 1 indicates a Type 2 summary. NUM = 2 indicates a Type 2 summary.	I	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
NUMCON	MAIN MIXER SUMARY SWTABL	Number of constituents considered.	I	
NUMPLT	MAIN	Total number of plots. (NUMPLT = NSWP+NTP+NPLT1+NPLT2).	I	
NUTCYC	MAIN	Cycle at which the summary of nutrient limitations begins.	I	
NWASTC	MAIN	Number of constant waste dischargers.	I	
NWASTV	MAIN	Number of variable waste dischargers.	I	
OAMUP(J)	MAIN	1-AMUP(J).	R	
OBDATA(I, J,K)	MAIN	I^{th} observed data point for the J^{th} constituent at the K^{th} location. J = 1,NUMCON, K = 1,NDATA, and I = 1.3). (There are three data points for constituent J at location K. These 3 points can correspond to either high, average and low; or day 1, day 2, and day 3, respectively).		
ODECAY(J, K)	MAIN	Coefficient used to determine mass of constituent K which is lost in junction J.	R	
OPHUP(J)	MAIN	1-PHUP(J).	R	
OREBOD(J)	MAIN	1-REBOD(J)	R	
OREGENT(J)	MAIN	1-REGEN(J).	R	
OREGEP(J)	MAIN	1-REGEP(J).		
PERCD	MAIN	For each quality time step, the percent of the algae decayed (DMASSX) which is biodegradable.	R	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
PHOCHL	MAIN	1./CHLPHO. Ratio of phosphorus to chlorophyll in algae.	R	
PHOT(I)	MAIN	Uniform algal phosynthesis rate in junction group I.	R	
PHOTO(J)	MAIN	Photosynthesis rate of algae in junction J	R	
PHOTOM	MAIN	Amount of oxygen added to a junction by constituent 4 (algae) through photosynthesis during one time step.	R	
PHUP(J)	MAIN	Phosphorus uptake rate by algae in junction J.	R	
PHUPP(J)	MAIN	Uniform phosphorus uptake rate in junction group I. (I =1,NR).	R	
PLT	SUMARY	Variable to determine if a summary table plot is desired. If PLT $\neq$ 0, a plot is obtained.		
Q(N)	MAIN MIXER	Flow in channel N.	R	
QCW(I)	MAIN	Constant waste flow for the I^{th} constant waste discharger.	R	
QIN(I)	MAIN	Inflow or withdrawl specified at junction J by the hydraulic program. Used for output of hydraulic summary table.	R	
QINWQ(J)	MAIN			
QINWQ(J)	MAIN	Flow rate of constant waste discharge or diversion at junction J. Discharges must be specified as negative, diversions must be positive.	R	
QNET(N)		New flow in channel N over full tidal cycle.	R	
R(N)	MAIN MIXER	Hydraulic radius of channel N. Taken as channel depth.	R	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
REBOD(J)	MAIN	Rate of BOD regeneration from drtrial pool in junction J.	R	
REBODD(I)	MAIN	Uniform BOD regeneration rate for junction group I. (I = 1,NR)	R	
REGEN(J)	MAIN	Rate of nitrogen regneration from detrital pool in junction J.	R	
REGENN(I)	MAIN	Uniform nitrogen regeneration rate for junction group I. (I = 1,NR)	R	
REGEP(J)	MAIN	Rate of phosphorus regeneration from detrital pool in junction J.	R	
REGEPP(I)	MAIN	Uniform phosphorus regeneration rate for junction group I. (I = 1,NR).	R	
REMASS	MAIN	Mass of oxygen (constituent 6) added to a junction through reacration during a quality time step.	R	
REOXK	MAIN	Constant reoxygenation coefficient.	R	
RES(I)	MAIN	Uniform algal respiration rate for junction group I. (I =1,NO).	R	
RESP(J)	MAIN	Respiration rate of algae in junction J.	R	
RESPM	MAIN	Mass of oxygen (constituent 6) depleted in a junction by constituent 4 (algae) through respiration during a quality time step.	R	
RMASSC	MAIN	Mass of constituent 5 (CBOD) regenerated through the detrital pool in a junction during a quality time step.	R	
RMASSN	MAIN	Amount of constituent 1 (nitrogen) regenerated through the detrital pool in a junction during a quality time step.	R	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
RMASSP	MAIN	Amount of constituent 3 (phosphorus) regenerated through the detrital pool in a junction during a quality time step.		
RMNODE(J)	MAIN SUMARY SWTABL	Distance of junction J from the upper boundary.	R	miles
RMDATA(K)	MAIN	Distance of the K^{th} data point from the upper boundary.	R	miles
SAREA	MAIN	Surface area of a junction.	R	ft^2
SADUM	MAIN	Sum of the surface area of adjacent junction. (Used for computing the average depth of a channel.)	R	
SEACON(K)	MAIN	Control parameter describing the seaward boundary conditions for each constituent. SEACON(K) = 1 concentration of constituent K at the seaward boundary is constant over the tidal cycle. 2 concentration of constituent K at the seaward boundary is variable over the tidal cycle.	I	
SLINE(J)	MAIN	Length of the shore line for junction J.	R	miles
STIME	MAIN SWTABL	Starting time for the quality program.	R	
TBFLOW(I, J)	MAIN	Total bank flow into junction J from the I^{th} bank load.	R	cfs
TEMP	MAIN	Temperature.	R	^oC
THETA(K)	MAIN	Temperature correction factor for decay rate (DECAY(K)) of constituent K.	R	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
TRISE	MAIN	Time of sunrise, with respect to CTIME.	R	hours
TSET	MAIN	Time of sunset, with respect to CTIME.	R	hours
V(N)	MAIN MIXER	Velocity in channel N.	R	
VBLOAD(K)	MAIN	Loading constituent K from a variable bank input.	R	
VOL(J)	MAIN	Volume of junction J.	R	ft^3
VOLFLW	MIXER	Volume of water flowing in a channel, during a quality time step.	R	ft^3
VOLQIN(J)	MAIN	Volume of diversion or waste water discharge for junction J during each time step. (VOLQIN(J) = QIN(J)*DELTQ).	R	ft^3
VOLSUM	MAIN	Sum of the volumes of adjacent junctions. (Used for computing average depth of a channel).	R	
VWLOAD(K)	MAIN	Variable waste load of constituent K. Computed for each junction receiving a variable waste input and for each time increment.	R	
XLOAD(I,K)	MAIN	Loading of constituent K for constant waste input I.	R	
XMASSN	MAIN	Amount of constituent K for constant waste input I.	R	
XMASSU	MAIN	Maximum amount of constituent 1 (NH_3) which can be taken up by algae during a quality time step.	R	
XMBOD	MAIN	Amount of constituent 5 (CBOD) decayed (oxidized) during a quality time step. XMBOD is also equal to the amount of oxygen required for that reaction to occur, e.g., for 1 pound of constituent 5 to decay, 1 pound of constituent 6 must be depleted.)	R	

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
XMNH3	MAIN	Amount of oxygen required for XMASSN pounds of constituent 1 to be transformed to constituent 2 (i.e. oxygen required for nitrification.	R	
XVOL	MAIN	Volume of the photic zone within a junction.	R	
Y(J)	MAIN SWTABL	Head at junction J.	R	ft
YMASSU	MAIN	Maximum aount of constituent 2 (NO2 + NO3) which can be utilized by algae during a quality time step.	R	
YMAXC(K)	MAIN	Maximum concentration of constituent K that can be plotted.	R	
YMINC(K)	MAIN	Minimum concentration of constituent K that can be plotted.	R	
YNEW(J)	MAIN SWTABL	Head a junction J for the next time step.	R	
ZMASSD	MAIN	Amount of constituent 3 (TPO4) settled out of a junction during a quality time step.	R	
ZMASSU	MAIN	Maximum amount of constituent 3 (TPO4) which can be taken up by algae during a quality time step.	R	
Unit 4	MAIN	Hydraulic extract tape.		
Unit 5	MAIN	Card reader.		
Unit 6	MAIN	Printer.		

VARIABLE	SUBROUTINE	DEFINITION	TYPE	UNITS
Unit 11	MAIN TPLOT	Stores data for time plots until the end of execution, then releases data for printing.		
Unit 22	SUMPLT SWPLOT TPLOT PPLOT	Stores slack water plots, summary plots, and time plots until execution terminates, then releases plots for printing.		

3.14 COMPUTER REQUIREMENTS

3.14.1 IBM JOB CONTROL LANGAUGE (JCL)

The JCL used to execute program DYNQUAL is as follows

```
    //JOB CARD

    //STEP1 EXEC PGM=DYNQUAL

    //STEPLIB DD DISP=SHR,VOL=(PRIVATE,RETAIN,SER=REGNA3),
    //  UNIT=3330-1,DSN=CNXXXX.XXX.LIBRARY

    //DD DSN=SYS2.FTG1LINK,DISP=SHR

    //GO.FT03F001 DD DCB=(RECFM=VBS,LRECL=504,BLKSIZE=5040),
    //  UNIT=SYSDA,SPACE=(TRK,(40,40)),DISP=(NEW,DELETE,DELETE),
    //  DSN=&&AB
-----------------------------------------------------------------

    //GO.FT04F001 DD DCB=(RECFM=VS,LRECL=504,BLKSIZE=5040),       reads
    //  DISP=(OLD,KEEP,KEEP),VOL=SER=USER99,UNIT=3330-1,          from
    //  DSN=CN.EPAXYZ.ACCT.DATA.SET.NAME                          disk
                                  or
    //GO.FT04F001 DD DCB=(RECFM=VS,LRECL=504,BLKSIZE=5040),       reads
    //  DISP=(OLD,KEEP,KEEP),VOL=SER=TAPE##,UNIT=2400,            from
    //  DSN=LEOTAPE,LABEL=(##,SL,EXPDT=98000)                     tape
-----------------------------------------------------------------

    //GO.FT11F001 DD DCB=(RECFM=VBS,LRECL=504,BLKSIZE=5040),
    //  UNIT=3330-1,VOL=SER=WORK99,SPACE=(TRK,(10,5),RLSE),
    //  DISP=(NEW,DELETE,DELETE),DSN=CNQSQM.LJC.TIMEP

    //GO.FT22F001 DD SYSOUT=A,DCB=RECFM=FBA

    //GO.FT06F001 DD SYSOUT=A

    //GO.FT05F001 DD *

       data deck goes here

    /*EOF
```

3.14.2 UNIVAC EXECUTIVE CONTROL LANGAUGE (ECL)

There are two steps involved in the execution of DYNQUAL on a UNIVAC system. The ECL for each of these steps is as follows:

STEP 1 - *Compile and Map DYNQUAL*

```
@RUN CARD
@PASSWORD
@SYM
@ASG,A  USERID*PGMFILE.
@ASG,A  USERID*ABS.
@USE  ASM$PF.,FTN*RLIB
@ASM,I  F2FRT,F2FRT
     F$FRT  30
     PR      6
     PU      1
     CR      5
     APR    22
     END
@FTN,IS
@ADD  USERID*PGMFILE.DYNQUAL
@MAP,I  USERID*ABS.DYNQUAL
LIB FTN*RLIB
   -------------------------------   DYNQUAL source deck
@FIN                                   goes here
```

STEP 2 - *Execute DYNQUAL*

```
@RUN CARD
@PASSWORD
@SYM
@ASG,A USERID*ABS.
@COPY,A  USERID*ABS.DYNQUAL
@FREE  USERID*ABS.
@ASG,A  USERID*1500CFS
@USE  4.,USERID*1500CFS
@ASG,T  USERID*TEMPFILE.11
@XQT  DYNQUAL
   data deck goes here
@FIN
```

3.14.3 EXECUTION TIMES

The time required to execute DYNQUAL is dependent on the computer used, the network size, the computational time step, the length of the run, and the number of constituents modeled. Typical execution times (CPU) for DYNQUAL on an IBM 370/168 are given below in Table 3.1. All of the runs in Table 3.1 were on a network with 133 junctions and 139 channels and used a computational time step of 1/2 hour. DYNQUAL requires approximately 275K of storage for execution.

Number of Constituents	Length of Run (days)	CPU (sec)
2	2	6.0
2	11	17.5
2	105	166.8
3	11	24.5
3	42	78.0
6	1	8.1
6	11	42.0
6	21	93.2
6	42	180.0

TABLE 3.1 DYNQUAL EXECUTION TIMES

CHAPTER 4

SAMPLE INPUTS AND OUTPUTS

4.1 THE MODEL NETWORK

The Potomac Estuary model network is composed of 133 junctions and 139 channels. Figures 4.1 through 4.6 depict the Potomac estuary and the configuration of channels and junctions used by the Dynamic Potomac Estuary Model.

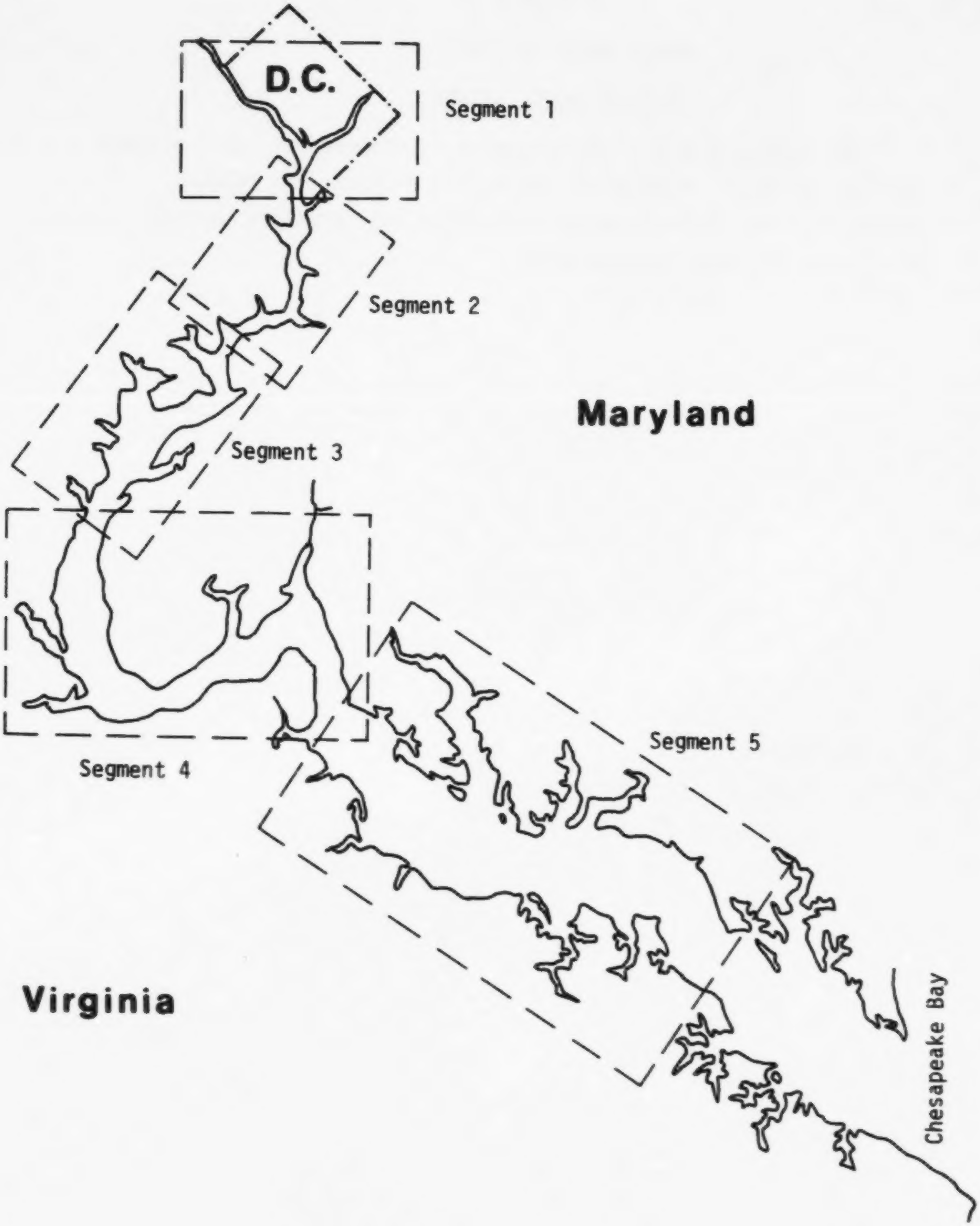

D.C.
Segment 1
Segment 2
Maryland
Segment 3
Segment 4
Segment 5
Virginia
Chesapeake Bay

FIGURE 4.1 THE POTOMAC ESTUARY

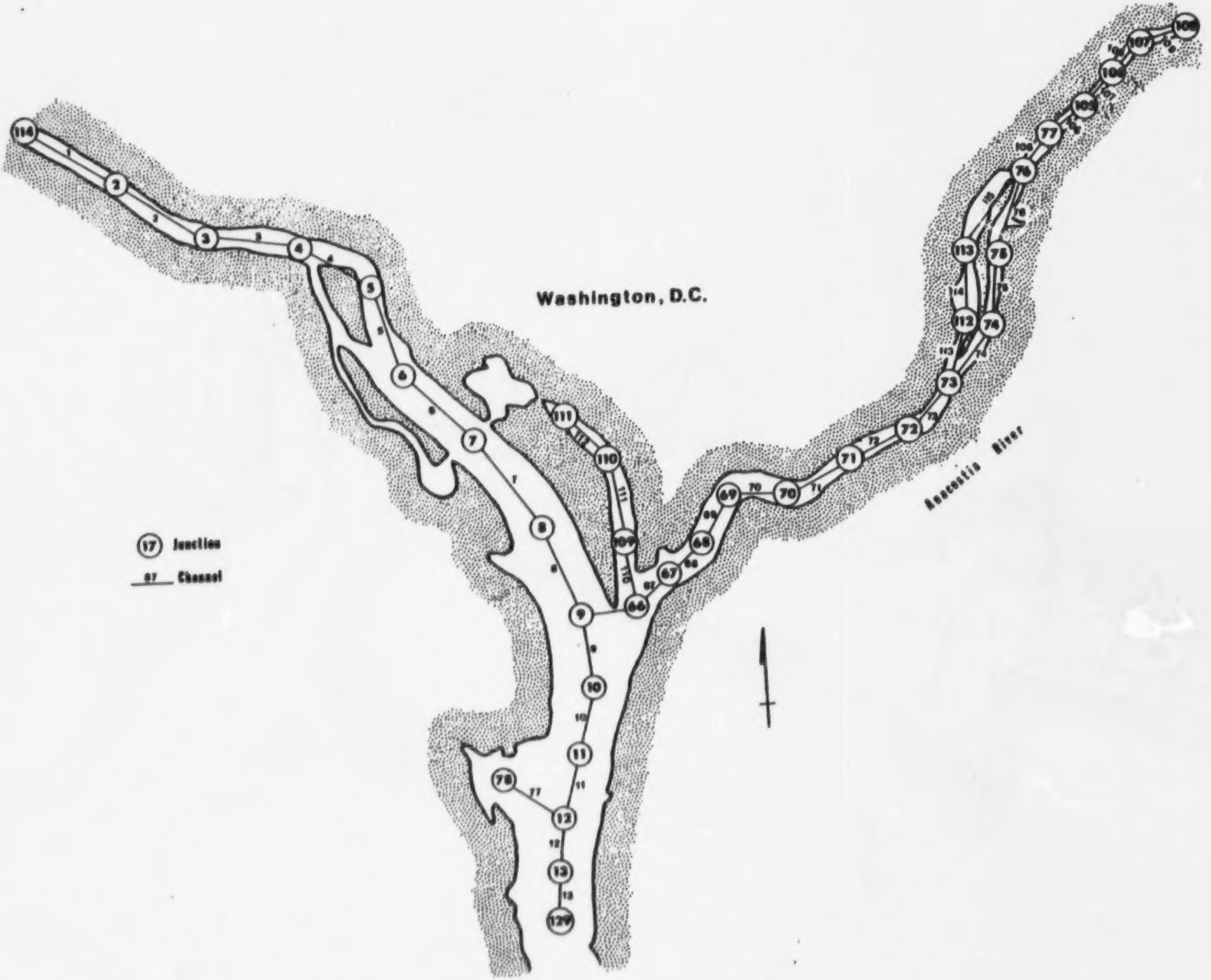

Washington, D.C.
Anacostia River
17 Junction
87 Channel
114
2
3
4
5
6
7
8
9
10
11
12
13
129
78
66
67
68
69
70
71
72
73
74
75
76
77
105
106
107
108
109
110
111
112
113

FIGURE 4.2 POTOMAC ESTUARY MODEL NETWORK - SEGMENT 1

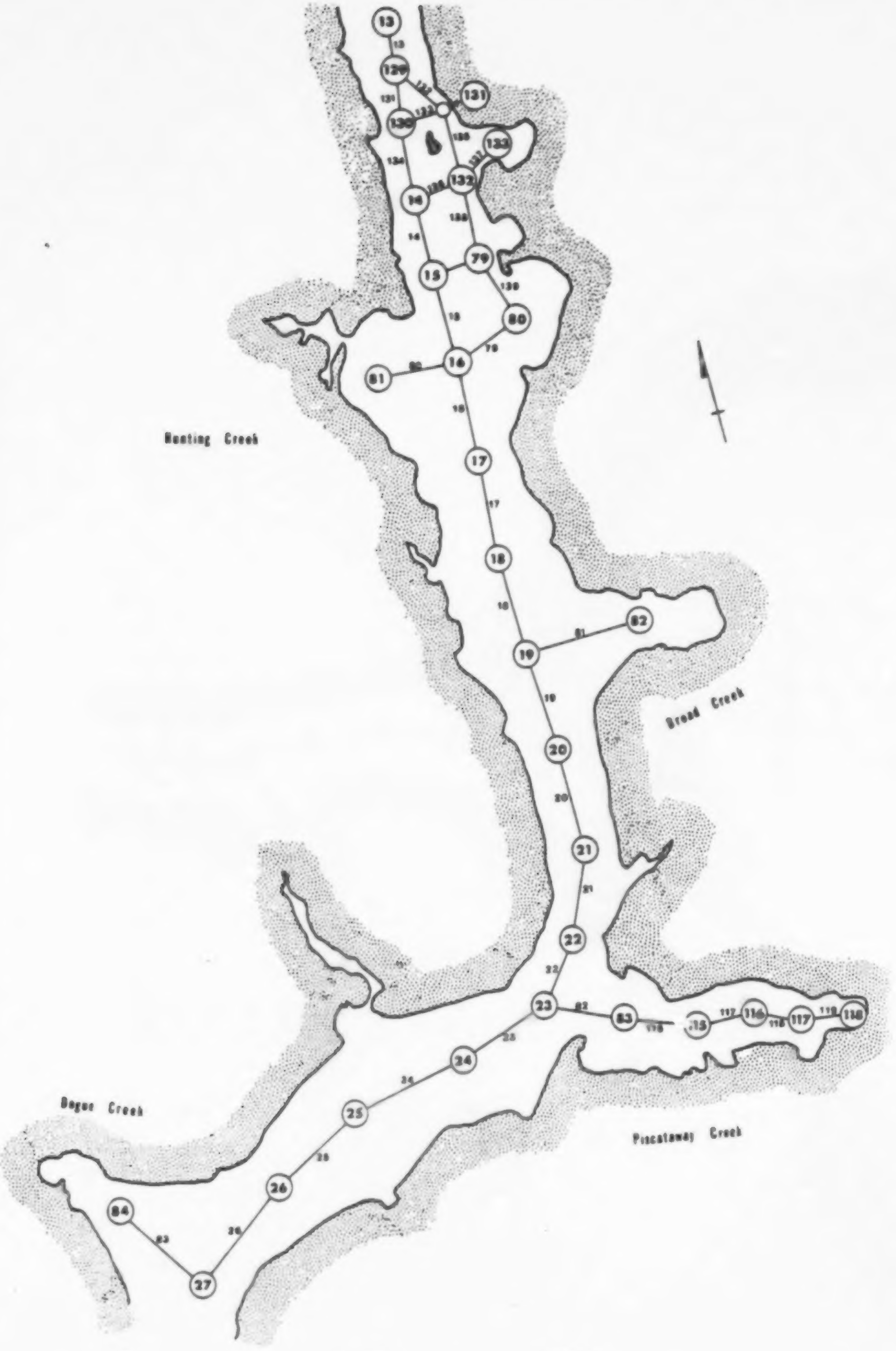

13
129
131
130
133
132
14
79
15
80
16
81
Hunting Creek
17
18
82
19
Broad Creek
20
21
22
23
83
115
116
117
118
24
25
Dogue Creek
Piscataway Creek
26
84
27

FIGURE 4.3 POTOMAC ESTUARY MODEL NETWORK - SEGMENT 2

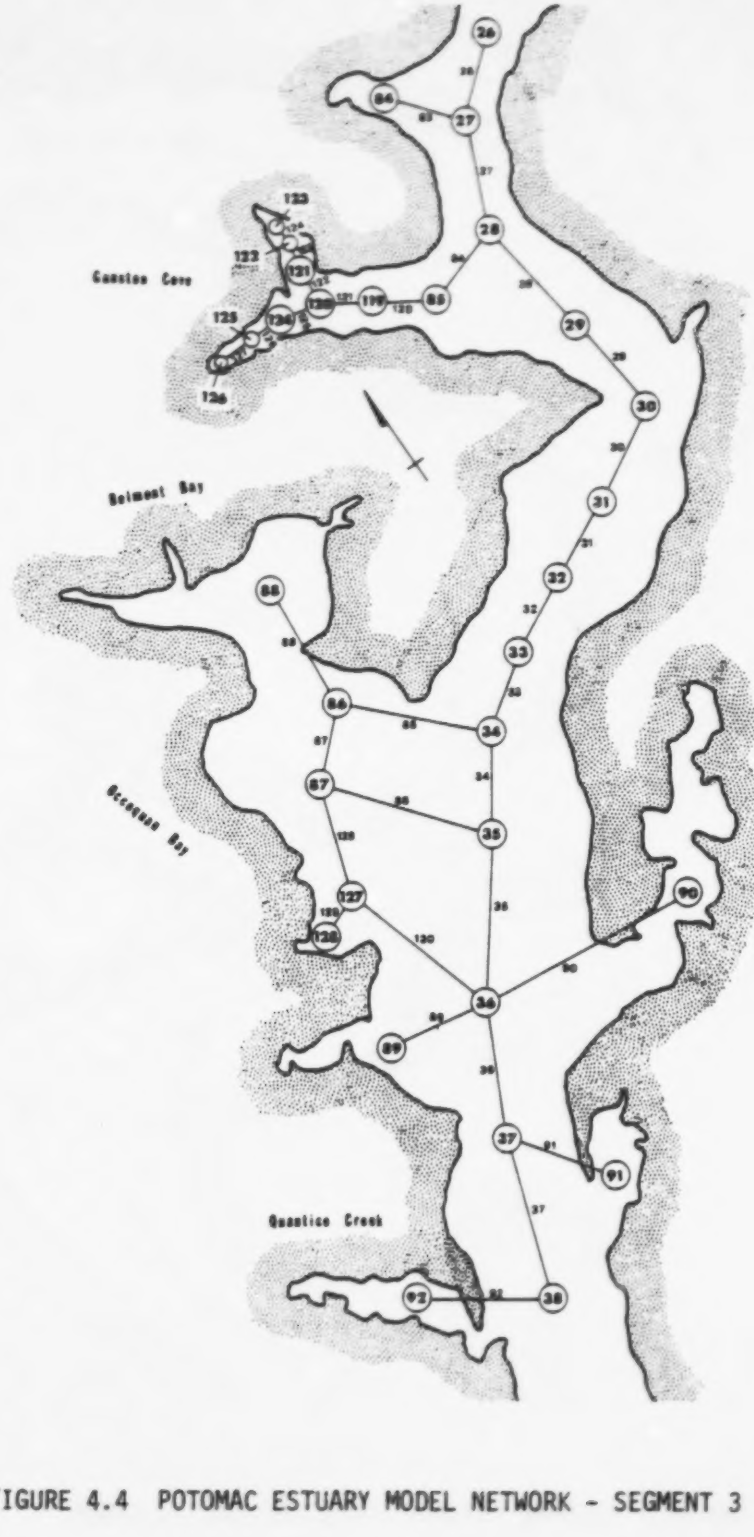

Gunston Cove
Belmont Bay
Occoquan Bay
Mattawoman Creek
Quantico Creek
26
84
27
28
85
119
120
121
122
123
125
126
29
30
31
32
33
88
86
34
87
35
127
128
90
36
89
37
91
38
92

FIGURE 4.4 POTOMAC ESTUARY MODEL NETWORK - SEGMENT 3

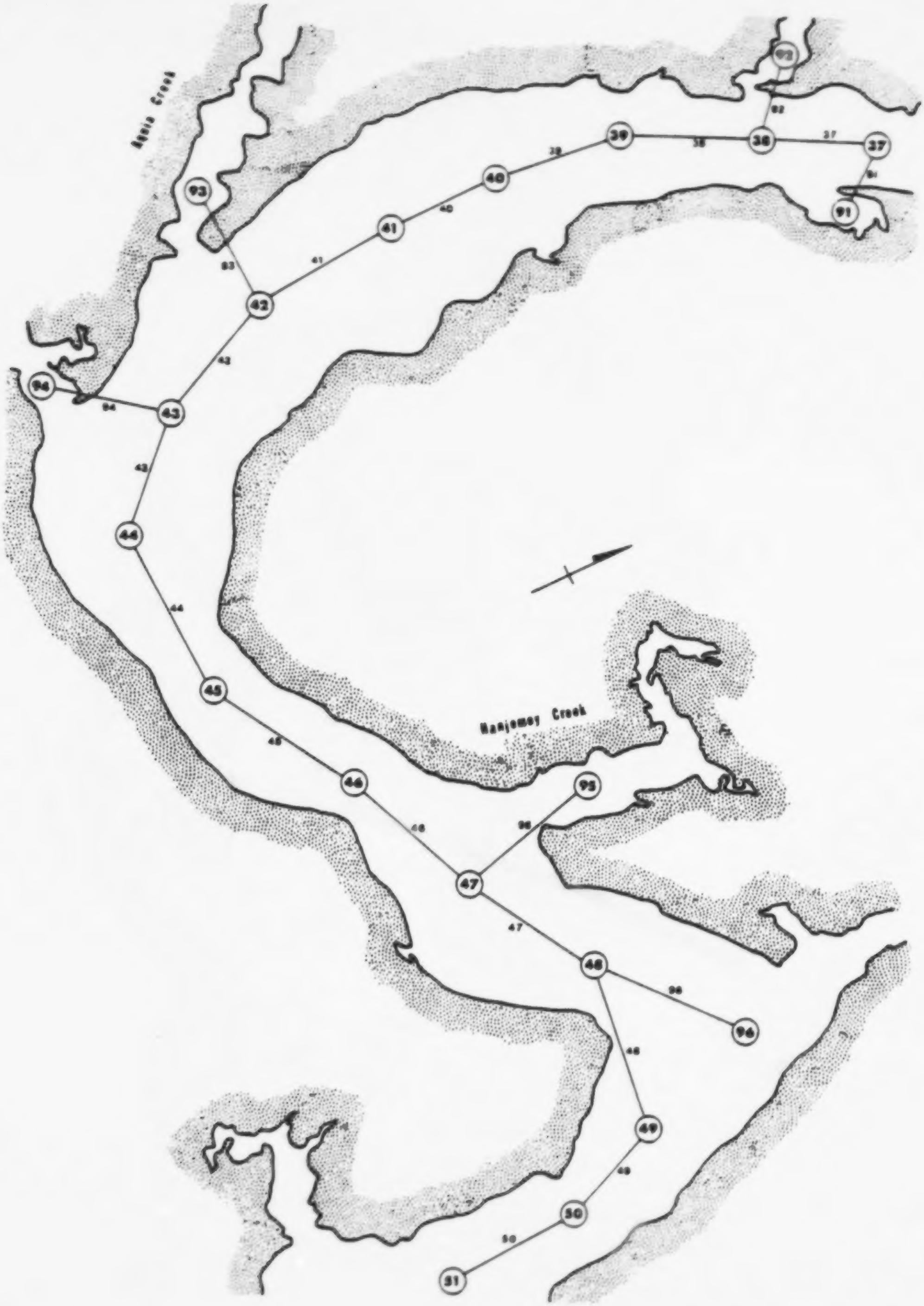

Aquia Creek
Nanjemoy Creek
92
92
37
38
37
39
38
91
91
40
39
41
40
93
93
42
41
94
94
43
42
43
44
44
45
45
46
46
95
95
47
47
48
96
96
48
49
49
50
50
51

FIGURE 4.5 POTOMAC ESTUARY MODEL NETWORK - SEGMENT 4

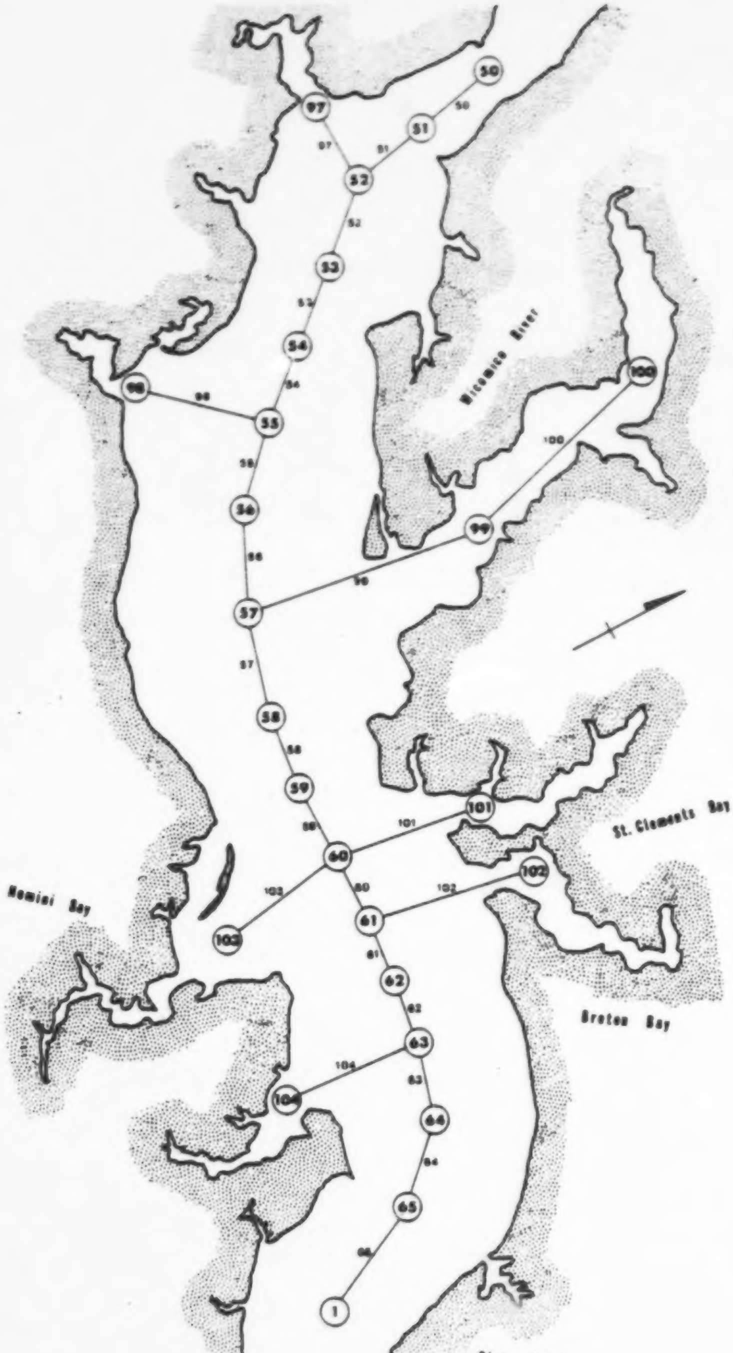

50
51
97
52
53
54
98
55
56
57
58
59
60
61
62
63
64
65
1
99
100
101
102
103
104
Wicomico River
St. Clements Bay
Nomini Bay
Breton Bay
Piney Point

FIGURE 4.6 POTOMAC ESTUARY MODEL NETWORK - SEGMENT 5

4.2 SAMPLE REGAN INPUT/OUTPUT

--- *data deck listing* ---

```
THIS RUN FINDS THE COEFFICIENTS FOR A MEAN TIDAL CONDITION AT PINEY POINT
      25          7          10   .00001        12.5         0.         0.
      .5     -.37        1.      -.27       1.5     -.09        2.      .09
     2.5      .33        3.       .57       3.5      .75        4.      .93
     4.5     1.03        5.      1.03       5.5     1.03        6.      .95
     6.5      .93        7.       .83       7.5      .67        8.      .57
     8.5      .39        9.       .27       9.5      .09       10.     -.01
    10.5     -.17       11.      -.27      11.5     -.29       12.     -.37
    12.5     -.37
```

--- *output listing* ---

```
THIS RUN FINDS THE COEFFICIENTS FOR A MEAN TIDAL CONDITION AT PINEY POINT           ENVIRONMENTAL PROTECTION AGENCY
                                                                                      LEAST SQUARES CURVE FITTING


         NUMBER OF DATA POINTS            NUMBER OF COEFFICIENTS
               (NDATA)                          (NCOEFF)

                 25                                7


         TIDAL PERIOD (HOURS)             OMEGA (2*PI/PERIOD)
               (PERIOD)                          (W)

               12.50                            0.5027


         MAXIMUM NUMBER OF                MAXIMUM RESIDUAL
         ITERATIONS ALLOWED                   ALLOWED

                 10                             0.0000


         TIME SHIFT                       PHASE ANGLE SHIFT
          (TSHIFT)                            (PSHIFT)

            0.0                                 0.0
```

```
******************************   SUMMARY OF INPUT DATA   ******************************

         OBSERVATION NO.               TIME            VALUE
     -------------------------------------------------------------

               1                       0.50           -0.370
               2                       1.00           -0.270
               3                       1.50           -0.090
               4                       2.00            0.090
               5                       2.50            0.330
               6                       3.00            0.570
               7                       3.50            0.750
               8                       4.00            0.930
               9                       4.50            1.030
              10                       5.00            1.030
              11                       5.50            1.030
              12                       6.00            0.950
              13                       6.50            0.930
              14                       7.00            0.830
              15                       7.50            0.670
              16                       8.00            0.570
              17                       8.50            0.390
              18                       9.00            0.270
              19                       9.50            0.090
              20                      10.00           -0.010
              21                      10.50           -0.170
              22                      11.00           -0.270
              23                      11.50           -0.290
              24                      12.00           -0.370
              25                      12.50           -0.370
```

```
  I  -----------  I
  I  SIGMA XY(J)  I                                    SIGMA XX(K,J)
J I  -----------  I
  I               I K =    1           2           3           4           5           6           7
  I---------------I--------------------------------------------------------------------------------------
  I               I
1 I    8.265591   I    25.000000   -0.000011   -0.000015   -0.000029   -0.000028   -0.000034   -0.000061
  I               I
2 I    2.757092   I    -0.000011   12.500003   -0.000006   -0.000009   -0.000008    0.000003    0.000015
  I               I
3 I   -0.837080   I    -0.000015   -0.000006   12.500008   -0.000007   -0.000017   -0.000009    0.000024
  I               I
4 I   -0.267349   I    -0.000029   -0.000009   -0.000007   12.500005   -0.000037   -0.000043   -0.000010
  I               I
5 I   -8.495359   I    -0.000028   -0.000006   -0.000017   -0.000037   12.499975   -0.000036   -0.000055
  I               I
6 I   -0.608171   I    -0.000034    0.000003   -0.000009   -0.000043   -0.000036   12.499970   -0.000045
  I               I
7 I    0.194272   I    -0.000061    0.000015    0.000024   -0.000010   -0.000059   -0.000045   12.499974
  I               I


                          ******************************
                                   SOLUTION
                          ******************************

                      NUMBER OF ITERATIONS          MAXIMUM RESIDUAL

                               2                        .000002


                THE CURVE WHICH BEST FITS THE OBSERVED DATA IS GIVEN BY

Y(T)  =   0.329999  +   0.220547 SIN(VT)  +  -0.066968 SIN(2VT)  +  -0.021389 SIN(3VT)

                    +  -0.678829 COS(VT)  +  -0.048655 COS(2VT)  +   0.015540 COS(3VT)
```

```
******************************  SUMMARY OF OUTPUT DATA  ******************************

OBSERVATION        TIME        OBSERVED        PREDICTED        RESIDUAL
-------------------------------------------------------------------------------

     1             0.50         -0.370         -0.3509          0.0191
     2             1.00         -0.270         -0.2616          0.0086
     3             1.50         -0.090         -0.1101         -0.0201
     4             2.00          0.090          0.0945          0.0045
     5             2.50          0.330          0.3300         -0.0000
     6             3.00          0.570          0.5655         -0.0045
     7             3.50          0.750          0.7701          0.0201
     8             4.00          0.930          0.9216         -0.0086
     9             4.50          1.030          1.0109         -0.0191
    10             5.00          1.030          1.0419          0.0119
    11             5.50          1.030          1.0268         -0.0032
    12             6.00          0.950          0.9783          0.0283
    13             6.50          0.930          0.9055         -0.0245
    14             7.00          0.830          0.8114         -0.0186
    15             7.50          0.670          0.6960          0.0260
    16             8.00          0.570          0.5600         -0.0100
    17             8.50          0.390          0.4086          0.0186
    18             9.00          0.27           0.2514         -0.0186
    19             9.50          0.0            0.1000          0.0100
    20            10.00         -0.0           -0.0360         -0.0250
    21            10.50         -0.1           -0.1514          0.0186
    22            11.00         -0.270         -0.2455          0.0265
    23            11.50         -0.290         -0.3183         -0.0283
    24            12.00         -0.370         -0.3648          0.0032
    25            12.50         -0.370         -0.3819         -0.0119

TOTAL RESIDUAL =    0.38679
```

4.3 SAMPLE DYNHYD INPUT/OUTPUT

-- data deck listing --

```
POTOMAC ESTUARY HYDRAULICS  -  133 JUNCTION NETWORK
SIMULATION OF A MEAN TIDAL CONDITION   FLOW = 11,000 CFS AT CHAIN BRIDGE
CONTROL DATA
  133  139 2000  90.   0.
 1500   40   10
  114    9   25   34   38   42   51   56   59    1
 1590    1
 2001 2001
JUNCTION DATA
    1   -0.3515336154880.       0.0    55     0     0     0     0
    2    2.0017  4332467.       0.0     1     2     0     0     0
    3    1.9992  4565733.       0.0     2     3     0     0     0
    4    1.9982  4443556.       0.0     3     4     0     0     0
    5    1.9945  4665733.       0.0     4     5     0     0     0
    6    1.9906  8442756.       0.0     5     6     0     0     0
    7    1.9815  8887111.       0.0     6     7     0     0     0
    8    1.9739 12806311.       0.0     7     8     0     0     0
    9    1.9616 13219578.       0.0     8     9    66     0     0
   10    1.9469  8664933.       0.0     9    10     0     0     0
   11    1.9419  7109689.       0.0    10    11     0     0     0
   12    1.9305  9442556.       0.0    11    12    77     0     0
   13    1.9198  8885791.       0.0    12    13     0     0     0
   14      1.90  5940600.        0.0   14   134   136     0     0
   15      1.87 10561100.        0.0   14    15    78     0     0
   16      1.85 11331200.        0.0   15    16    79    80     0
   17    1.8259 19773808.       0.0    16    17     0     0     0
   18    1.7958 22884304.       0.0    17    18     0     0     0
   19    1.7818 19329456.       0.0    18    19    81     0     0
   20    1.7512 15552445.       0.0    19    20     0     0     0
   21    1.7312 13108489.       0.0    20    21     0     0     0
   22    1.6974 10775622.       0.0    21    22     0     0     0
   23    1.6820 14441556.              22    23    82     0     0
   24    1.6522 26772416.       0.0    23    24     0     0     0
   25    1.6213 29216368.       0.0    24    25     0     0     0
   26    1.5891 23561920.       0.0    25    26     0     0     0
   27    1.5516 29327456.       0.0    26    27    83     0     0
   28    1.4916 42769216.       0.0    27    28    84     0     0
   29    1.4265 53878112.       0.0    28    29     0     0     0
   30    1.3803 49380768.       0.0    29    30     0     0     0
   31    1.3222 49323456.       0.0    30    31     0     0     0
   32    1.2836 53544832.       0.0    31    32     0     0     0
   33    1.2456 43324656.       0.0    32    33     0     0     0
   34    1.2172 59099280.       0.0    33    34    85     0     0
   35    1.1705 81094880.       0.0    34    35    86     0     0
   36    1.1134120531440.       0.0    35    36    89    90   130
   37    1.0386 92648128.       0.0    36    37    91     0     0
   38    0.9312 83983200.       0.0    37    38    92     0     0
   39    0.8531119976000.       0.0    38    39     0     0     0
   40    0.7663176474992.       0.0    39    40     0     0     0
   41    0.6967190184175.       0.0    40    41     0     0     0
   42    0.6268184962992.       0.0    41    42    93     0     0
   43    0.5384166300054.       0.0    42    43    94     0     0
   44    0.4492209735824.       0.0    43    44     0     0     0
   45    0.3657121420144.       0.0    44    45     0     0     0
   46    0.2076219956000.       0.0    45    46     0     0     0
   47    0.1209186296064.       0.0    46    47    95     0     0
   48    0.0094172187776.       0.0    47    48    96     0     0
   49   -0.0836156524240.       0.0    48    49     0     0     0
   50   -0.1543102646128.       0.0    49    50     0     0     0
   51   -0.2074168077488.       0.0    50    51     0     0     0
 52   -0.2323235286256.      0.0    51   52   97    0    0
 53   -0.2600218845712.      0.0    52   53    0    0    0
 54   -0.2900193294636.      0.0    53   54    0    0    0
 55   -0.3089291719426.      0.0    54   55   98    0    0
 56   -0.3285321309952.      0.0    55   56    0    0    0
 57   -0.3423349818880.      0.0    56   57   99    0    0
 58   -0.3508371925504.      0.0    57   58    0    0    0
 59   -0.3629268773969.      0.0    58   59    0    0    0
 60   -0.3737325490432.      0.0    59   60  101  103    0
 61   -0.3798246839504.      0.0    60   61  102    0    0
 62   -0.3834225954800.      0.0    61   62    0    0    0
 63   -0.3794241396144.      0.0    62   63  104    0    0
 64   -0.3754293052416.      0.0    63   64    0    0    0
 65   -0.3684279410688.      0.0    64   65    0    0    0
 66     1.9635   4960000.    0.0    66   67  110    0    0
 67     1.9662   3240000.    0.0    67   68    0    0    0
 68     1.9687   2680000.    0.0    68   69    0    0    0
 69     1.9711   3200000.    0.0    69   70    0    0    0
 70     1.9736   2360000.    0.0    70   71    0    0    0
 71     1.9779   2800000.    0.0    71   72    0    0    0
 72     1.9844   2640000.    0.0    72   73    0    0    0
 73     1.9898   1760000.    0.0    73   74  113    0    0
 74     1.9966   1360000.    0.0    74   75    0    0    0
 75     2.0012   1320000.    0.0    75   76    0    0    0
 76     2.0077   1000000.    0.0    76  105  115    0    0
 77     2.0106   1060000.    0.0   105  106    0    0    0
 78     1.9323   6332000.           77    0    0    0    0
 79       1.87  14961500.     0.0   78  138  139    0    0
 80       1.85  15071500.     0.0   79  139
 81     1.8491  21218000.           80    0    0    0    0
 82     1.7878  16219000.    0.0    81    0    0    0    0
 83     1.6929  12920000.    0.0    82  116    0    0    0
 84     1.5563  17884992.    0.0    83    0    0    0    0
 85     1.5179  31200000.    0.0    84  120    0    0    0
 86     1.2150  80550000.    0.0    85   87   88    0    0
 87     1.2012  55666544.    0.0    86   87  128    0    0
 88     1.2471  69430992.    0.0    88    0    0    0    0
 89     1.1294  19218000.    0.0    89    0    0    0    0
 90     1.1347  74540992.    0.0    90    0    0    0    0
 91     1.0498  22772992.    0.0    91    0    0    0    0
 92     0.9629  29326992.    0.0    92    0    0    0    0
 93     0.7511101090992.     0.0    93    0    0    0    0
 94     0.6816  76984992.    0.0    94    0    0    0    0
 95     0.3576124974992.     0.0    95    0    0    0    0
 96     0.0962163856000.     0.0    96    0    0    0    0
 97    -0.2348  71736000.    0.0    97    0    0    0    0
 98    -0.3826  80540000.    0.0    98    0    0    0    0
 99    -0.3702300699994.     0.0    99  100    0    0    0
100     0.0216201300000.     0.0   100    0    0    0    0
101    -0.4216154080000.     0.0   101    0    0    0    0
102    -0.4315135306000.     0.0   102    0    0    0    0
103    -0.3877126086000.     0.0   103    0    0    0    0
104    -0.3916  92648000.    0.0   104    0    0    0    0
105     2.0126    800000.    0.0   106  107    0    0    0
106     2.0149    560000.    0.0   107  108    0    0    0
107     2.0156   1000000.    0.0   108  109    0    0    0
108     2.0166    540000.   -20.   109    0    0    0    0
109     1.9651   3600000.    0.0   110  111    0    0    0
110     1.9659   3200000.    0.0   111  112    0    0    0
111     1.9652   1600000.    0.0   112    0    0    0    0
```

```
  112     2.0062  2800000.       0.0   113   114     0     0     0
  113     2.0211  2400000.       0.0   114   115     0     0     0
  114     2.1090   996711.  -11000.      1     0     0     0     0
  115     1.6995 11600000.       0.0   116   117     0     0     0
  116     1.7026  6600000.       0.0   117   118     0     0     0
  117     1.7045  4666657.       0.0   118   119     0     0     0
  118     1.7066  3777770.       0.0   119     0     0     0     0
  119     1.5242 11560000.       0.0   120   121     0     0     0
  120     1.5269  7200000.       0.0   121   122   125     0     0
  121     1.5309  6080000.       0.0   122   123     0     0     0
  122     1.5337  3720000.       0.0   123   124     0     0     0
  123     1.5364  2160000.       0.0   124     0     0     0     0
  124     1.5291  8200000.       0.0   125   126     0     0     0
  125     1.5316  3800000.       0.0   126   127     0     0     0
  126     1.5354  1200000.             127     0     0     0     0
  127     1.2017 12333080.       0.0   128   129   130     0     0
  128     1.2298 10000000.       0.0   129     0     0     0     0
  129       1.90  8030800.       0.0   130   131   132     0     0
  130       1.90  4940500.       0.0   131   133   134     0     0
  131       1.90  2570300.    -479.0   132   133   135     0     0
  132       1.90  6600700.       0.0   135   136   137   138     0
  133       1.90  3960400.       0.0   137     0     0     0     0
CHANNEL DATA
    1   7614.     274.    4152.0  18.56   0.020-1.90449     2  114
    2   7075.     800.   26131.9  32.67   0.020 0.30452     2    3
    3   2351.     955.   33959.7  35.56   0.020 0.23600     3    4
    4   4065.    1183.   24567.9  20.77   0.020 0.32848     4    5
    5   3749.    1521.   26410.5  17.36   0.020 0.30793     5    6
    6   5597.    1945.   26196.3  13.47   0.020 0.31513     6    7
    7   3599.    2350.   26225.1  11.16   0.020 0.32046     7    8
    8   5439.    2912.   30441.9  10.45   0.020 0.28387     8    9
    9   4045.    2920.   35774.7  12.25   0.020 0.28035     9   10
   10   1690.    2953.   43274.0  14.56   0.017 0.23616    10   11
   11   3696.    3258.   44847.0  13.77   0.017 0.23174    11   12
   12   3010.    3503.   44042.6  12.57   0.017 0.24344    12   13
   13   2270.    2475.   39785.5  16.08   0.017 0.27437    13  129
   14   3690.    2100.   33180.     15.8   0.017     0.3    14   15
   15   4180.    2340.   29952.     12.8   0.017     0.3    15   16
   16   3855.    3738.   50759.5  13.58   0.017 0.26816    16   17
   17   6177.    4671.   60286.4  12.91   0.017 0.23327    17   18
   18   2640.    5506.   60959.9  11.07   0.017 0.23897    18   19
   19   5396.    4117.   62670.0  15.22   0.017 0.24435    19   20
   20   3274.    3337.   60623.7  18.17   0.017 0.25840    20   21
   21   5280.    3052.   60180.6  19.72   0.017 0.26528    21   22
   22   3009.    3319.   76971.4  23.19   0.017 0.21068    22   23
   23   5227.    4221.   91408.6  19.29   0.017 0.21452    23   24
   24   5069.    5967.   82151.9  13.77   0.017 0.22040    24   25
   25   5014.    5355.   80322.6  15.00   0.017 0.23472    25   26
   26   4605.    4388.   73405.8  16.73   0.017 0.26567    26   27
   27   8765.    5469.   88224.1  16.13   0.017 0.23674    27   28
   28   9081.    6604.  101276.8  15.34   0.017 0.24705    28   29
   29   6706.    6223.  112189.0  18.03   0.017 0.23976    29   30
   30   8342.    7308.  118032.9  16.15   0.017 0.24301    30   31
   31   5597.    8833.  126069.4  14.27   0.017 0.24266    31   32
   32   5650.    7562.  134497.4  17.79   0.017 0.24380    32   33
   33   4045.    7908.  134688.9  17.73   0.017 0.25731    33   34
   34   6706.   10233.  140505.3  13.68   0.017 0.26193    34   35
   35   8026.   13474.  172403.4  12.80   0.014 0.27905    35   36
   36  10507.   10224.  190830.3  18.67   0.014 0.32559    36   37
   37  13464.    7824.  176749.1  22.59   0.014 0.39007    37   38
```

38	9715.	8934.	181020.1	20.26	0.014	0.42121	38	39
39	12144.	12130.	207392.6	17.10	0.014	0.40690	39	40
40	10676.	16807.	236116.5	14.05	0.014	0.40996	40	41
41	11246.	16701.	236963.9	14.19	0.014	0.46581	41	42
42	12640.	14315.	220656.1	15.42	0.014	0.59212	42	43
43	12330.	13802.	221357.3	16.04	0.014	0.66536	43	44
44	10624.	11116.	198484.4	17.86	0.014	0.81313	44	45
45	17529.	8074.	168169.3	20.83	0.014	1.00756	45	46
46	10560.	10217.	187353.8	18.34	0.014	0.97969	46	47
47	14256.	12745.	205985.9	16.16	0.014	0.98872	47	48
48	12975.	11875.	215773.0	16.17	0.014	1.06056	48	49
49	12038.	10599.	236331.4	22.30	0.014	1.00881	49	50
50	9620.	10325.	246189.1	23.85	0.014	0.99265	50	51
51	6461.	17716.	337303.5	19.04	0.014	0.75213	51	52
52	10540.	25490.	444595.3	17.44	0.014	0.60939	52	53
53	9451.	21717.	389187.9	17.92	0.014	0.72553	53	54
54	6611.	26187.	418799.1	17.32	0.014	0.69764	54	55
55	10665.	30413.	536040.6	17.63	0.014	0.58223	55	56
56	10137.	31129.	604968.0	19.44	0.014	0.54108	56	57
57	8712.	33034.	635735.4	19.25	0.014	0.59238	57	58
58	12302.	27018.	549942.2	20.36	0.014	0.71397	58	59
59	10612.	25500.	506362.3	19.86	0.014	0.79615	59	60
60	11616.	29075.	553632.9	19.04	0.014	0.77384	60	61
61	6705.	28258.	582908.5	20.63	0.014	0.75720	61	62
62	8712.	27676.	587217.7	21.22	0.014	0.76198	62	63
63	8659.	25729.	607281.9	23.60	0.014	0.75113	63	64
64	8659.	24386.	663242.9	27.20	0.014	0.69604	64	65
65	16104.	22510.	717908.3	31.89	0.014	-0.64889	1	65
66	2600.	3200.	46282.1	20.71	0.024	0.01674	9	66
67	2640.	1500.	33752.8	22.50	0.024	-0.02426	66	67
68	2380.	1250.	29150.1	23.32	0.024	-0.02564	67	68
69	2510.	1250.	29153.5	23.32	0.024	-0.02356	68	69
70	2640.	1150.	26599.1	23.13	0.024	-0.02304	69	70
71	3035.	750.	15672.3	20.90	0.024	-0.03556	70	71
72	3430.	750.	9806.8	13.08	0.024	-0.04981	71	72
73	3200.	750.	9875.7	13.17	0.024	-0.04306	72	73
74	3035.	550.	4023.1	7.32	0.026	-0.06187	73	74
75	3430.	400.	5450.2	13.63	0.026	-0.03890	74	75
76	3565.	350.	3434.4	9.81	0.026	-0.05114	75	76
77	4830.	1311.	18159.5	13.85	0.022	-0.00773	12	78
78	2100.	4500.	26100.	5.8	0.020	-0.1	15	79
79	3450.	4200.	36960.	8.8	0.020	-0.1	16	80
80	3405.	6231.	30167.4	4.84	0.022	-0.01563	16	81
81	5550.	2922.	16513.6	5.65	0.022	-0.01926	19	82
82	3700.	3412.	18271.7	5.36	0.022	-0.04977	23	83
83	4320.	4140.	17364.6	4.20	0.022	-0.02999	27	84
84	10530.	6214.	31580.0	5.08	0.022	-0.05672	28	85
85	6250.	8000.	47361.8	5.92	0.022	0.01095	34	86
86	10000.	7250.	64932.3	8.96	0.022	-0.11295	35	87
87	7350.	9930.	80807.3	8.14	0.022	0.08218	36	87
88	12655.	5401.	30211.7	5.60	0.022	-0.08503	86	88
89	8190.	2347.	7945.5	3.39	0.022	-0.12455	36	89
90	16230.	4601.	43228.8	9.40	0.022	-0.08654	36	90
91	6450.	3531.	11486.8	3.26	0.022	-0.11580	37	91
92	12130.	2408.	9826.4	4.08	0.022	-0.19095	38	92
93	26700.	3786.	18352.9	4.85	0.022	-0.39106	42	93
94	22410.	3435.	12978.8	3.78	0.022	-0.39595	43	94
95	24810.	5027.	17449.5	3.47	0.022	-0.47392	47	95
96	30900.	5303.	33384.8	6.30	0.022	-0.42867	48	96
97	17080.	4200.	21240.5	5.06	0.022	-0.20791	52	97

```
  98  19950.    4037.  18346.9    4.55   0.022-0.29928   55   98
  99  36830.    8160. 105807.1   12.97   0.022-0.31556   57   99
 100  24650.    8160.  26277.4    3.22   0.022-0.56871   99  100
 101  32250.    4778.  43213.3    9.05   0.022-0.15873   60  101
 102  33000.    4100.  36960.8    9.02   0.022-0.15133   61  102
 103  26310.    4792.  29044.9    6.06   0.022-0.24327   60  103
 104  16140.    5740.  40281.6    7.02   0.022-0.07958   63  104
 105   3200.     300.   3705.3   12.35   0.026-0.02762   76   77
 106   3165.     300.   3511.3   11.71   0.028-0.02109   77  105
 107   2770.     250.   3456.2   13.83   0.028-0.01531  105  106
 108   2640.     250.   2201.6    8.81   0.028-0.01746  106  107
 109   2700.     200.   1116.1    5.58   0.028-0.01193  107  108
 110   3400.     950.  19502.2   20.53   0.024-0.00945   66  109
 111   3400.     930.  20951.6   22.53   0.024-0.00505  109  110
 112   3500.     900.  22075.7   24.53   0.024-0.00160  110  111
 113   3200.      90.   1081.4   12.02   0.035-0.11903   73  112
 114   4200.      50.    558.5   11.17   0.035-0.06776  112  113
 115   2700.      70.    312.4    4.46   0.035-0.14475   76  113
 116   3350.    3000.  18881.4    6.29   0.035-0.03274   83  115
 117   2850.    3200.  19836.6    6.20   0.035-0.01884  115  116
 118   1850.    2200.  12319.1    5.60   0.035-0.01892  116  117
 119   1480.    1200.   4206.7    3.51   0.035-0.03113  117  118
 120   4300.    4000.  31069.9    7.77   0.035-0.05357   85  119
 121   2500.    4050.  31071.3    7.67   0.035-0.04047  119  120
 122   3000.    2000.   9543.6    4.77   0.035-0.04981  120  121
 123   2200.    1600.   5405.1    3.38   0.035-0.04779  121  122
 124   2000.     500.   1991.6    3.98   0.035-0.06342  122  123
 125   2750.    3000.  17319.6    5.77   0.035-0.03033  120  124
 126   3000.    1200.   6564.2    5.47   0.035-0.03509  124  125
 127   2600.     400.   1352.4    3.38   0.035-0.06840  125  126
 128   5300.    4500.  31461.4    6.99   0.035 0.05842   87  127
 129   9000.     750.   2855.6    3.81   0.035-0.12660  127  128
 130  12500.    2700.  10405.1    3.86   0.035-0.26420   36  127
 131   2650.    1800.  28440.     15.8   0.017    00.2   129  130
 132   2610.     900.   9720.     10.8   0.020    0.15   129  131
 133   1600.    1650.  14520.      8.8   0.020   -0.10   130  131
 134   2490.    2000.  35600.     17.8   0.017   -0.25    14  130
 135   2590.    1350.   9180.      6.8   0.020    0.1    131  132
 136   2280.    2700.  15660.      5.8   0.020   -0.1     14  132
 137   2700.    1500.   8700.      5.8   0.022   -0.1    132  133
 138   3750.    1800.  15840.      8.8   0.020   -0.1     79  132
 139   4140.    2250.  19800.      8.8   0.020    0.1     79   80
SEAWARD BOUNDARY
   7
     12.5        .33   .220567  -.066968  -.021389  -.678829  -.048655   .015540
HYDEX CONTROL
POTOMAC ESTUARY HYDRAULICS  -  133 JUNCTIONS   -  139 CHANNELS
MEAN TIDAL CONDITION  FLOW = 11,000 CFS @ CHAIN BRIDGE, 479 CFS @ BLUE PLAINS
   20
/*
```

-- *output listing* --

```
POTOMAC ESTUARY HYDRAULICS  -  137 JUNCTION NETWORK                                    ENVIRONMENTAL PROTECTION AGENCY
SIMULATION OF A MEAN TIDAL CONDITION   FLOW = 11,000 CFS AT CHAIN BRIDGE               DYNAMIC FLOW IN A 2-DIMENSIONAL SYSTEM


       NUMBER OF      NUMBER OF
       JUNCTIONS      CHANNELS
         (NJ)           (NC)

         137            139


        NUMBER OF          HYDRAULIC TIME
     HYDRAULIC CYCLES       STEP, IN SEC.       STARTING TIME
         (NCYC)               (DELT)               (TZERO)

          2000                 90.0                  0.0


     PRINTOUT BEGINS        NO. OF CYCLES        NO. OF JUNCTIONS
        AT CYCLE          BETWEEN PRINTOUT           PRINTED
        (IPPRINT)             (INTRVL)               (NOPRT)

          1500                  40                     17


    RESTART DATA STORED       NO. OF CYCLES BETWEEN
        AT CYCLE              UPDATE OF RESTART DATA
        (PUNCYC)                    (INTPUN)

          2001                       2001


    IS SUBROUTINE HYDEX             DATA FOR HYDEX IS
         CALLED ?              STORED BEGINNING AT CYCLE
    (DOES HYDEXT = 1 ?)                  (ITAPE)

          YES                             1500
```

```
**********************************************   SUMMARY OF JUNCTION DATA   *************************************************

   JUNCTION     INITIAL HEAD    SURFACE AREA    INPUT - OUTPUT          CHANNELS ENTERING JUNCTION
----------------------------------------------------------------------------------------------------------

       1          -0.3515       536154880.          0.0            65     0     0     0     0
       2           2.0017         4332467.          0.0             1     2     0     0     0
       3           1.9992         4665733.          0.0             2     3     0     0     0
       4           1.9982         4443556.          0.0             3     4     0     0     0
       5           1.9965         4665733.          0.0             4     5     0     0     0
       6           1.9904         8442756.          0.0             5     6     0     0     0
       7           1.9815         9887111.          0.0             6     7     0     0     0
       8           1.9739        12806311.          0.0             7     8     0     0     0
       9           1.9616        13219578.          0.0             8     9    66     0     0
      10           1.9469         8664933.          0.0             9    10     0     0     0
      11           1.9419         7109689.          0.0            10    11     0     0     0
      12           1.9305         9442556.          0.0            11    12    77     0     0
      13           1.9193         8885791.          0.0            12    13     0     0     0
      14           1.9070         5940600.          0.0            14   134   135     0     0
      15           1.8700        10561100.          0.0            14    15    78     0     0
      16           1.8500        11331200.          0.0            15    16    79    80     0
      17           1.8257        19773806.          0.0            16    17     0     0     0
      18           1.7959        22984304.          0.0            17    18     0     0     0
      19           1.7818        19329456.          0.0            18    19    81     0     0
      20           1.7512        15552445.          0.0            19    20     0     0     0
      21           1.7312        13108489.          0.0            20    21     0     0     0
      22           1.6976        10775622.          0.0            21    22     0     0     0
      23           1.6820        14441556.          0.0            22    23    82     0     0
      24           1.6522        26772415.          0.0            23    24     0     0     0
      25           1.6213        29216369.          0.0            24    25     0     0     0
      26           1.5891        23661920.          0.0            25    26     0     0     0
      27           1.5516        29327456.          0.0            26    27    83     0     0
      28           1.4916        42769216.          0.0            27    28    84     0     0
      29           1.4255        53878112.          0.0            28    29     0     0     0
      30           1.3803        49380768.          0.0            29    30     0     0     0
      31           1.3222        49323456.          0.0            30    31     0     0     0
      32           1.2836        53544832.          0.0            31    32     0     0     0
      33           1.2455        43324656.          0.0            32    33     0     0     0
      34           1.2172        59099280.          0.0            33    34    85     0     0
      35           1.1705        81094890.          0.0            34    35    86     0     0
      36           1.1134       120531440.          0.0            35    36    89    90   130
      37           1.0395        92648128.          0.0            36    37    91     0     0
      38           0.9312        83983200.          0.0            37    38    92     0     0
      39           0.8531       119976000.          0.0            38    39     0     0     0
      40           0.7653       176474992.          0.0            39    40     0     0     0
      41           0.6967       190184175.          0.0            40    41     0     0     0
      42           0.6248       184962992.          0.0            41    42    93     0     0
      43           0.5386       166300064.          0.0            42    43    94     0     0
      44           0.4492       209735924.          0.0            43    44     0     0     0
      45           0.3657       121420144.          0.0            44    45     0     0     0
      46           0.2076       219956000.          0.0            45    46     0     0     0
      47           0.1209       186296064.          0.0            46    47    95     0     0
      48           0.0096       172187776.          0.0            47    48    96     0     0
      49          -0.0836       156524241.          0.0            48    49     0     0     0
      50          -0.1543       102646125.          0.0            49    50     0     0     0
      51          -0.2077       138977484.          0.0            50    51     0     0     0
```

```
 54      -0.2900     143294656.        0.0       53    54      0     0     0
 55      -0.3099     281719424.        0.0       54    55     98     0     0
 56      -0.3295     321309952.        0.0       55    56      0     0     0
 57      -0.3423     349816880.        0.0       56    57     99     0     0
 58      -0.3508     371925504.        0.0       57    58      0     0     0
 59      -0.3629     268723968.        0.0       58    59      0     0     0
 60      -0.3737     325450432.        0.0       59    60    101   103     0
 61      -0.3798     264939504.        0.0       60    61    102     0     0
 62      -0.3806     225554900.        0.0       61    62      0     0     0
 63      -0.3796     241396144.        0.0       62    63    104     0     0
 64      -0.3758     293052416.        0.0       63    64      0     0     0
 65      -0.3694     279410688.        0.0       64    65      0     0     0
 66       1.9535       4960000.        0.0       66    67    110     0     0
 67       1.9562       3240000.        0.0       67    68      0     0     0
 68       1.9687       2680000.        0.0       68    69      0     0     0
 69       1.9711       3200000.        0.0       69    70      0     0     0
 70       1.9736       2360000.        0.0       70    71      0     0     0
 71       1.9778       2900000.        0.0       71    72      0     0     0
 72       1.9844       2440000.        0.0       72    73      0     0     0
 73       1.9898       1760000.        0.0       73    74    113     0     0
 74       1.9946       1360000.        0.0       74    75      0     0     0
 75       2.0012       1320000.        0.0       75    76      0     0     0
 76       2.0072       1000000.        0.0       76   105    115     0     0
 77       2.0104       1040000.        0.0      105   106      0     0     0
 78       1.9323       6332000.        0.0       77     0      0     0     0
 79       1.8790      14961500.        0.0       78   138    139     0     0
 80       1.8500      15071500.        0.0       79   139      0     0     0
 81       1.6491      21218000.        0.0       80     0      0     0     0
 82       1.7878      16219000.        0.0       81     0      0     0     0
 83       1.6929      12920000.        0.0       82   114      0     0     0
 84       1.5563      17884992.        0.0       83     0      0     0     0
 85       1.5172      31200000.        0.0       84   120      0     0     0
 86       1.2150      80550000.        0.0       85    87     88     0     0
 87       1.2012      55666544.        0.0       86    87    128     0     0
 88       1.2471      69430992.        0.0       88     0      0     0     0
 89       1.1294      19216000.        0.0       89     0      0     0     0
 90       1.1347      74540992.        0.0       90     0      0     0     0
 91       1.0498      22772992.        0.0       91     0      0     0     0
 92       0.9629      29326992.        0.0       92     0      0     0     0
 93       0.7511     101090992.        0.0       93     0      0     0     0
 94       0.6814      76984992.        0.0       94     0      0     0     0
 95       0.3576     124974992.        0.0       95     0      0     0     0
 96       0.0962     163856000.        0.0       96     0      0     0     0
 97      -0.2348      71736000.        0.0       97     0      0     0     0
 98      -0.2826      80540000.        0.0       98     0      0     0     0
 99      -0.3702     300699994.        0.0       99   100      0     0     0
100       0.0216     201300000.        0.0      100     0      0     0     0
101      -0.4216     154080000.        0.0      101     0      0     0     0
102      -0.4315     135306000.        0.0      102     0      0     0     0
103      -0.3877     126086000.        0.0      103     0      0     0     0
104      -0.3916      92648000.        0.0      104     0      0     0     0
105       2.0125        800000.        0.0      106   107      0     0     0
106       2.0140        560000.        0.0      107   108      0     0     0
107       2.0154       1000000.        0.0      108   109      0     0     0
108       2.0156        540000.        0.0      109     0      0     0     0
109       1.9651       3600000.      -27.0      110   111      0     0     0
110       1.9559       3200000.        0.0      111   112      0     0     0
111       1.9642       1600000.        0.0      112     0      0     0     0
```

- 170 -

```
 115      1.6995    1108000.      0.0     116  117    0    0  0
 116      1.7026    6400000.      0.0     117  118    0    0  0
 117      1.7045    4466657.      0.0     118  119    0    0  0
 118      1.7066    3777770.      0.0     119    0    0    0  0
 119      1.5242    1156000.      0.0     120  121    0    0  0
 120      1.5249    7200000.      0.0     121  122  125    0  0
 121      1.5309    6080000.      0.0     122  123    0    0  0
 122      1.5337    3720000.      0.0     123  124    0    0  0
 123      1.5368    2160000.      0.0     124    0    0    0  0
 124      1.5291    9200000.      0.0     125  126    0    0  0
 125      1.5314    7800000.      0.0     126  127    0    0  0
 126      1.5354    1200000.      0.0     127    0    0    0  0
 127      1.2017    1233330.      0.0     128  129  130    0  0
 128      1.2279    1000000.      0.0     129    0    0    0  0
 129      1.9000    8030800.      0.0      13  131  132    0  0
 130      1.9000    4840500.      0.0     131  133  134    0  0
 131      1.9000    2970300.   -470.0     132  133  135    0  0
 132      1.9000    5600700.      0.0     135  136  137  138  0
 133      1.9000    7060400.      0.0     137    0    0    0  0
```

```
**************************************************   SUMMARY OF CHANNEL DATA   **************************************************

 CHANNEL     LENGTH     WIDTH      C.S. AREA     ROUGHNESS      VELOCITY      HYD. RADIUS          JUNCTIONS AT ENDS
-------------------------------------------------------------------------------------------------------------------------

    1         7914.       224.        4153.0       0.020       -1.99449          18.5               2      114
    2         7076.       800.       26136.0       0.020        0.30452          32.7               2        3
    3         2951.       955.       33959.8       0.020        0.23600          35.6               3        4
    4         4065.      1193.       24570.9       0.020        0.32848          20.8               4        5
    5         3749.      1521.       26404.6       0.020        0.39793          17.4               5        6
    6         5597.      1545.       26199.1       0.020        0.31513          13.5               6        7
    7         3590.      2350.       26226.0       0.020        0.32046          11.2               7        8
    8         5439.      2917.       30430.4       0.020        0.28387          10.4               8        9
    9         4065.      2923.       35770.0       0.020        0.28035          12.3               9       10
   10         1590.      2953.       43291.0       0.017        0.23616          14.7              10       11
   11         3596.      3258.       44862.7       0.017        0.23136          13.8              11       12
   12         3010.      3593.       44032.7       0.017        0.24346          12.6              12       13
   13         2270.      2475.       35798.0       0.017        0.27437          16.1              13      125
   14         3690.      2100.       33180.0       0.017        0.30000          15.8              14       15
   15         4180.      2340.       29952.0       0.017        0.30000          12.9              15       16
   16         3955.      3738.       50742.0       0.017        0.26816          13.6              16       17
   17         4177.      4671.       60302.6       0.017        0.23327          12.9              17       18
   18         2440.      5506.       60951.6       0.017        0.23897          11.1              18       19
   19         5386.      4117.       62660.7       0.017        0.24435          15.2              19       20
   20         3274.      3337.       60633.3       0.017        0.25840          18.2              20       21
   21         5280.      3052.       60185.4       0.017        0.26528          19.7              21       22
   22         3009.      3319.       76967.6       0.017        0.21069          23.2              22       23
   23         5227.      4271.       81423.0       0.017        0.21452          19.3              23       24
   24         5069.      5947.       82165.6       0.017        0.22040          13.8              24       25
   25         5016.      5355.       80325.0       0.017        0.23472          15.0              25       26
   26         4805.      4398.       73411.2       0.017        0.26567          16.7              26       27
   27         8765.      5452.       88214.9       0.017        0.23674          16.1              27       28
   28         9081.      6604.      101305.3       0.017        0.24705          15.3              28       29
   29         4706.      6223.      112200.5       0.017        0.23976          18.0              29       30
   30         9342.      7398.      118024.1       0.017        0.24301          15.1              30       31
   31         5597.      8833.      126046.9       0.017        0.24266          16.3              31       32
   32         5650.      7562.      134527.9       0.017        0.24360          17.9              32       33
   33         4065.      7908.      134673.2       0.017        0.25731          17.0              33       34
   34         6706.     10273.      140536.6       0.017        0.25183          13.7              34       35
   35         9026.     13474.      172467.2       0.014        0.27905          12.8              35       36
   36        10507.     10224.      150892.0       0.014        0.32559          18.7              36       37
   37        13764.      7824.      176744.1       0.014        0.39007          22.6              37       38
   38         9715.      8934.      181002.7       0.014        0.42121          20.3              38       39
   39        12144.     12130.      207423.1       0.014        0.49690          17.1              39       40
   40        10976.     15637.      236138.3       0.014        0.40998          14.1              40       41
   41        11246.     16701.      236987.1       0.014        0.46581          14.2              41       42
   42        12460.     14316.      220752.7       0.014        0.59212          15.4              42       43
   43        12230.     13802.      221393.0       0.014        0.66534          15.0              43       44
   44        10824.     11116.      198531.7       0.014        0.81313          17.9              44       45
   45        17529.      8374.      168181.4       0.014        1.00756          23.9              45       46
   46        10560.     10217.      147379.7       0.014        0.97969          18.3              46       47
   47        14256.     12735.      205959.2       0.014        0.98872          16.2              47       48
   48        12926.     11875.      215748.7       0.014        1.05036          19.2              48       49
   49        12038.     10599.      236357.7       0.014        1.01561          22.5              49       50
   50         9920.     11325.      246251.3       0.014        0.99265          23.6              50       51
   51    [illegible] [illegible] [illegible]  [illegible]  [illegible]     [illegible]            51       52
```

54	6811.	24187.	416919.0	0.014	0.69764	17.3	54	55
55	17665.	30413.	536181.3	0.014	0.58223	17.6	55	56
56	10137.	31129.	605147.8	0.014	0.54108	19.4	56	57
57	8712.	33034.	635904.5	0.014	0.59238	19.7	57	58
58	12302.	27018.	550086.4	0.014	0.71357	20.4	58	59
59	10512.	25507.	506430.0	0.014	0.79615	19.9	59	60
60	11516.	29075.	553587.7	0.014	0.77384	19.0	60	61
61	6705.	26259.	582962.6	0.014	0.75720	20.6	61	62
62	9712.	27676.	587294.7	0.014	0.76198	21.2	62	63
63	8659.	25729.	607204.5	0.014	0.75113	23.4	63	64
64	5459.	24365.	563299.1	0.014	0.69604	27.2	64	65
65	16104.	22510.	717343.9	0.014	-0.64839	31.0	1	65
66	2400.	3200.	66272.0	0.024	0.01674	20.7	9	66
67	2640.	1500.	33750.0	0.024	-0.02426	22.5	66	67
68	2780.	1250.	29150.0	0.024	-0.02564	23.3	67	68
69	2510.	1250.	29150.0	0.024	-0.02356	23.3	68	69
70	2640.	1150.	26599.5	0.024	-0.02306	23.1	69	70
71	2035.	750.	15475.0	0.024	-0.03556	20.9	70	71
72	2450.	750.	9910.0	0.024	-0.04981	13.1	71	72
73	2300.	750.	9977.5	0.024	-0.04306	13.2	72	73
74	2035.	550.	6726.0	0.028	-0.06187	7.3	73	74
75	3430.	400.	5452.0	0.028	-0.03890	13.6	74	75
76	3565.	350.	3433.5	0.028	-0.05114	9.8	75	76
77	4830.	1311.	16157.3	0.022	-0.00773	13.9	12	78
78	2100.	4500.	26100.0	0.020	-0.10000	5.8	15	79
79	3650.	4200.	36960.0	0.020	-0.10000	8.8	16	80
80	3405.	5291.	30158.0	0.022	-0.01663	4.8	16	81
81	5550.	2922.	16509.3	0.022	-0.01924	5.6	19	82
82	3700.	3412.	16288.3	0.022	-0.04977	5.4	23	83
83	4320.	4140.	17398.0	0.022	-0.02999	4.2	27	84
84	10530.	6214.	31567.1	0.022	-0.08672	5.1	28	85
85	6250.	8000.	47360.0	0.022	0.01095	5.0	34	86
86	10000.	7250.	64960.0	0.022	-0.11286	9.0	35	87
87	7350.	9930.	60830.2	0.022	0.08218	8.1	86	87
88	12955.	5401.	30245.6	0.022	-0.08503	5.6	86	88
89	8190.	2347.	7956.3	0.022	-0.12455	3.4	36	89
90	14200.	4601.	43249.4	0.022	-0.09456	9.4	36	90
91	6450.	3531.	11511.1	0.022	-0.11580	3.7	37	91
92	17180.	2408.	9824.6	0.022	-0.19095	4.1	38	92
93	26700.	3786.	10862.1	0.022	-0.39106	4.0	42	93
94	27410.	3435.	12984.3	0.022	-0.30595	3.8	43	94
95	26810.	5027.	17643.7	0.022	-0.47392	3.5	47	95
96	30900.	5303.	33408.9	0.022	-0.42867	6.7	48	96
97	17080.	4200.	41252.0	0.022	-0.29791	5.1	52	97
98	19950.	4037.	18366.3	0.022	-0.29920	4.6	55	98
99	34930.	6160.	105935.2	0.022	-0.31556	13.0	57	99
100	26450.	8160.	26275.2	0.022	-0.58871	3.2	99	100
101	32250.	4778.	43240.9	0.022	-0.15873	9.1	60	101
102	33000.	4100.	36982.0	0.022	-0.15133	9.0	61	102
103	24310.	4792.	29035.5	0.022	-0.24327	6.1	60	103
104	14140.	5740.	40296.9	0.022	-0.07858	7.0	63	104
105	3300.	300.	3705.0	0.028	-0.02762	12.4	76	77
106	2165.	300.	3513.0	0.028	-0.02109	11.7	77	105
107	2770.	250.	3457.5	0.028	-0.01531	13.8	105	106
108	2440.	250.	2202.5	0.028	-0.01746	8.8	106	107
109	2700.	200.	1116.0	0.028	-0.01193	5.4	107	108
110	3400.	550.	19503.5	0.024	-0.00965	20.5	66	109
111	3400.	931.	20952.9	0.024	-0.00505	22.5	109	110
112	3500.	930.	22977.1	0.024	-0.01160	26.5	110	111

```
 115      2700.     70.     312.2    0.035   -0.14475    4.5        76   113
 116      3350.   3000.   16870.0    0.035   -0.03274    6.7        83   115
 117      2850.   3200.   15840.0    0.035   -0.01886    6.2       115   116
 118      1850.   2200.   12320.0    0.035   -0.01892    5.6       116   117
 119      1480.   1200.    4212.0    0.035   -0.03113    3.5       117   118
 120      4300.   4000.   31080.0    0.035   -0.05357    7.8        85   119
 121      2500.   4350.   31063.5    0.035   -0.04047    7.7       119   120
 122      3000.   2000.    9540.0    0.035   -0.04981    4.8       120   121
 123      3300.   1601.    5408.0    0.035   -0.06779    3.6       121   122
 124      2800.    500.    1090.0    0.035   -0.06342    4.0       122   123
 125      2750.   3000.   17310.0    0.035   -0.03333    5.8       120   124
 126      3000.   1200.    6564.0    0.035   -0.03509    5.5       124   125
 127      2400.    400.    1352.0    0.035   -0.06840    3.4       125   126
 128      5300.   4500.   31455.0    0.035    0.05842    7.0        87   127
 129      2000.    750.    2857.5    0.035   -0.12660    3.8       127   128
 130     17500.   2700.   10422.0    0.035   -0.24420    3.0        36   127
 131      2450.   1600.   20740.0    0.017    0.20000   15.8       129   130
 132      2610.    900.    9720.0    0.020    0.15000   10.8       129   131
 133      1900.   1650.   14520.0    0.020   -0.13000    8.8       130   131
 134      2490.   2000.   35600.0    0.017   -0.25000   17.8        14   130
 135      2580.   1350.    9180.0    0.020    0.10000    6.8       131   132
 136      2280.   2700.   15640.0    0.020   -0.10000    5.8        14   132
 137      2700.   1500.    8700.0    0.022   -0.10000    5.8       132   133
 138      3750.   1800.   15840.0    0.020   -0.10000    8.8        79   132
 139      4140.   2250.   19800.0    0.020    0.10000    8.8        79    80
```

```
***************************   TIDAL CONDITIONS AT THE SEAWARD BOUNDARY   ***************************

          TIDAL PERIOD IS 12.50 HOURS

          MEAN SEA LEVEL IS 0.330000 FEET

          THE HEAD AT THE SEAWARD BOUNDARY IS GIVEN BY

             HEAD =  0.330000 +  0.220557 SIN(WT) + -0.066968 SIN(2WT) + -0.021389 SIN(3WT)
                               + -0.679829 COS(WT) + -0.048655 COS(2WT) +  0.015540 COS(3WT)
```

```
SYSTEM STATUS AFTER CYCLE 1500        37.50 HOURS                      SYSTEM STATUS AFTER CYCLE 1540        38.50 HOURS

JUNCTION     HEAD     CHANNEL     VELOCITY       FLOW                  JUNCTION     HEAD     CHANNEL     VELOCITY       FLOW
 NUMBER      (FT)     NUMBER       (FPS)        (CFS)                   NUMBER      (FT)     NUMBER       (FPS)        (CFS)

  114       2.0946                                                       114       1.5460
                          1        2.68719      11116.0                                          1        2.77931      11149.1

    9       1.7052                                                         9       1.2156
                          8       -0.59606     -17567.4                                          8       -0.69200     -19582.5
                          9        0.71760      25170.7                                          9        0.88733      29806.5
                         66       -0.08960      -5976.6                                         66       -0.12396      -7919.2

   25       1.3615                                                        25       0.8550
                         24       -0.68053     -73987.4                                         24       -1.10543     -85749.6
                         25        0.94669      74677.0                                         25        1.18102      89990.8

   34       0.7446                                                        34       0.5568
                         33       -0.92819    -122948.3                                         33       -1.12353    -145355.8
                         34        0.90338     124372.6                                         34        1.10361     147634.4
                         85        0.09423       4255.8                                         85        0.09894       4148.4

   38       0.7048                                                        38       0.4285
                         37       -1.06171    -185596.2                                         37       -1.26316    -217836.5
                         38        1.07587     192578.9                                         38        1.28493     227375.1
                         92       -0.18137      -1679.5                                         92       -0.27682      -2391.0

   42       0.6692                                                        42       0.2796
                         41       -0.92129    -215521.6                                         41       -1.17307    -261691.9
                         42        1.04786     228687.7                                         42        1.28252     276970.7
                         93       -0.32158      -5650.2                                         93       -0.25402      -4290.7

   51      -0.2571                                                        51      -0.3356
                         50       -1.20634    -296269.1                                         50       -1.35872    -332514.9
                         51        0.89669     301668.0                                         51        0.99811     334424.3

   54      -0.3191                                                        54      -0.3776
                         53       -0.81642    -317098.6                                         53       -0.87738    -339565.3
                         54        0.77055     322250.4                                         54        0.81627     340260.7

   59      -0.3756                                                        59      -0.3927
                         58       -0.67218    -369470.0                                         58       -0.62302    -362156.1
                         60        0.77034     374143.6                                         60        0.66686     337657.1

    1      -0.3819                                                         1      -0.2416
                         65       -0.56705    -392317.6                                         65       -0.34523    -262779.1
```

```
SYSTEM STATUS AFTER CYCLE 1580     39.50 HOURS                  SYSTEM STATUS AFTER CYCLE 1620     40.50 HOURS

JUNCTION    HEAD     CHANNEL    VELOCITY      FLOW              JUNCTION    HEAD     CHANNEL    VELOCITY      FLOW
 NUMBER     (FT)     NUMBER      (FPS)        (CFS)              NUMBER     (FT)     NUMBER      (FPS)        (CFS)

  114      0.0623                                                  114      0.4823
                        1      2.87157      11173.3                                     1      2.96801      11103.9

    9      0.5091                                                    9      0.1087
                        8     -0.73495     -18701.1                                     8     -0.67922     -17024.0
                        9      0.87496      27844.6                                     9      0.79610      24172.6
                       66     -0.11419      -7077.6                                    66     -0.09170      -5532.6

   25      0.3607                                                   25     -0.0540
                       24     -1.03907     -77466.5                                    24     -0.87727     -63203.7
                       25      1.10403      81201.7                                    25      0.92811      66215.2

   34      0.1816                                                   34     -0.1517
                       33     -1.03272    -130491.0                                    33     -0.85842    -107419.1
                       34      1.02790     133595.7                                    34      0.88069     111405.6
                       85      0.07106       2779.1                                    85      0.03820       1027.8

   38      0.1140                                                   38     -0.1955
                       37     -1.15786    -196729.6                                    37     -0.95037    -165908.9
                       38      1.18746     206547.4                                    38      1.01986     174695.2
                       92     -0.31338      -2473.4                                    92     -0.31732      -2277.8

   42      0.0314                                                   42     -0.2206
                       41     -1.08445    -245814.7                                    41     -0.94062    -209122.3
                       42      1.24673     265006.2                                    42      1.09494     226867.4
                       93     -0.34445      -5589.5                                    93     -0.41596      -6360.7

   51     -0.3238                                                   51     -0.1342
                       50     -1.31982    -322722.9                                    50     -0.94107    -231875.3
                       51      0.95190     319219.4                                    51      0.63842     216533.5

   54     -0.3136                                                   54     -0.0342
                       53     -0.79283    -303848.5                                    53     -0.41510    -163446.9
                       54      0.70692     295861.6                                    54      0.37021     160496.4

   59     -0.2156                                                   59      0.1844
                       58     -0.37251    -206071.9                                    58      0.15979      90057.3
                       59      0.34275     195237.7                                    59     -0.24229    -126252.5

    1      0.0966                                                    1      0.5455
                       65      0.03351      23777.2                                    65      0.54244     414873.9
```

```
SYSTEM STATUS AFTER CYCLE 1660     41.50 HOURS                 SYSTEM STATUS AFTER CYCLE 1700     42.50 HOURS

JUNCTION    HEAD    CHANNEL    VELOCITY      FLOW              JUNCTION    HEAD    CHANNEL    VELOCITY      FLOW
 NUMBER     (FT)    NUMBER      (FPS)       (CFS)               NUMBER     (FT)    NUMBER      (FPS)       (CFS)

  114      0.1169                                                 114    -0.1471
                       1       3.07773     11076.6                                    1       3.05734     11056.7

    9     -0.2705                                                   9    -0.5511
                       8      -0.64547    -15451.7                                    8      -0.61904    -14320.3
                       9       0.79926     20751.3                                    9       0.64191     18254.5
                      66      -0.06924     -4093.4                                   66      -0.05225     -3041.7

   25     -0.3927                                                  25    -0.6303
                      24      -0.72157    -50555.8                                   24      -0.58899    -40393.1
                      25       0.76043     52917.3                                   25       0.61504     41986.9

   34     -0.4323                                                  34    -0.5997
                      33      -0.77661    -85820.6                                   33      -0.40962    -60019.1
                      34       0.72503     89703.1                                   34       0.48681     59627.2
                      85       0.00283        96.8                                   85       0.05360      1758.5

   38     -0.4154                                                  38    -0.4710
                      37      -0.78816   -130531.7                                   37      -0.42032    -49358.6
                      38       0.80539    136319.9                                   38       0.39811     67252.0
                      92      -0.27374     -1803.2                                   92      -0.04140      -252.6

   42     -0.3462                                                  42    -0.2243
                      41      -0.68967   -151475.9                                   41      -0.15960    -35335.7
                      42       0.76690    159002.0                                   42       0.08222     17251.1
                      93      -0.34233     -5277.1                                   93      -0.02953      -430.7

   51      0.3467                                                  51     0.9968
                      50      -0.13289    -73396.5                                   50       0.81462    209292.4
                      51       0.01580      5496.3                                   51      -0.64312   -229744.9

   56      0.5746                                                  56     1.0060
                      53       0.20251     82079.1                                   53       0.77364    292953.5
                      54      -0.25932   -113270.3                                   54      -0.69601   -313592.7

   59      0.5859                                                  59     1.0855
                      58       0.69976    404071.1                                   58       0.87966    517771.6
                      59      -0.82544   -440599.5                                   59      -0.99002   -538009.6

    1      0.9217                                                   1     1.0419
                      65       0.91739    694510.0                                   65       0.85959    644331.5
```

```
SYSTEM STATUS AFTER CYCLE 1740      43.50 HOURS           SYSTEM STATUS AFTER CYCLE 1780      44.50 HOURS

JUNCTION    HEAD    CHANNEL    VELOCITY      FLOW        JUNCTION    HEAD    CHANNEL    VELOCITY      FLOW
 NUMBER     (FT)    NUMBER       (FPS)       (CFS)        NUMBER     (FT)    NUMBER       (FPS)       (CFS)

  114     -0.3466                                          114     -0.4679
                       1       3.09860     11042.2                              1       3.19469     11012.5

    9     -0.7589                                            9     -0.8526
                       8      -0.59415    -13426.7                              8      -0.51180    -11374.5
                       9       0.58377     16248.0                              9       0.41492     11440.9
                      66      -0.03819     -2197.7                             66      -0.00225      -128.9

   25     -0.7362                                           25     -0.4215
                      24      -0.37930    -25743.6                             24       0.29528     20548.1
                      25       0.37839     25625.2                             25      -0.37188    -25832.0

   34     -0.4702                                           34      0.1193
                      33      -0.03377     -4085.6                             33       0.82761    103941.2
                      34      -0.08680    -10774.9                             34      -0.96896   -122992.4
                      85       0.24087      8122.9                             85       0.22929      8836.3

   38     -0.1027                                           38      0.3596
                      37       0.46377     77694.9                             37       1.30481    223660.4
                      38      -0.54550    -94045.3                             38      -1.35181   -238390.7
                      92       0.51637      3636.0                             92       0.53440      4401.2

   42      0.2643                                           42      0.6116
                      41       0.71750    164661.4                                      1.19140    280533.7
                      42      -0.92080   -199571.3                             42      -1.37576   -304876.4
                      93       0.67450     10727.8                             93       0.71436     12417.5

   51      1.1822                                           51      1.1480
                      50       1.35481    352729.3                             50       1.40297    364555.3
                      51      -0.98812   -357894.0                             51      -0.98936   -357649.8

   54      1.2307                                           54      1.1405
                      53       0.85016    371096.2                             53       0.78918    331398.9
                      54      -0.82155   -374534.1                             54      -0.79552   -320053.6

   59      1.1985                                           59      1.0547
                      58       0.71135    421345.0                             58       0.37120    218515.6
                      59      -0.75870   -419722.4                             59      -0.36866   -199782.3

    1      0.0763                                            1      0.9114
                      65       0.49160    368176.5                             65       0.07250     53993.7
```

```
SYSTEM STATUS AFTER CYCLE 1820       45.50 HOURS             SYSTEM STATUS AFTER CYCLE 1960       45.50 HOURS

JUNCTION     HEAD     CHANNEL     VELOCITY       FLOW        JUNCTION     HEAD     CHANNEL     VELOCITY       FLOW
 NUMBER      (FT)      NUMBER       (FPS)        (CFS)        NUMBER      (FT)      NUMBER       (FPS)        (CFS)

  114      -0.7012                                             114       0.8983
                          1        3.02511      10653.6                                1        2.79061      10742.0

    9      -0.4554                                               9       0.4061
                          8       -0.00239        -55.4                                8        0.14971       3958.6
                          9       -0.45314     -13021.6                                9       -0.77931     -23405.8
                         66        0.17001       9934.7                               66        0.24866      15271.1

   25       0.2283                                              25       0.8087
                         24        1.18873      93663.9                               24        1.25596      97091.7
                         25       -1.21546     -88652.1                               25       -1.38271    -101274.8

   34       0.6560                                              36       1.0071
                         33        1.20072     155944.9                               33        1.18446     150585.9
                         34       -1.19676    -161609.1                               34       -1.05796    -146584.2
                         85       -0.08521      -1691.7                               85       -0.19632      -8509.3

   38       0.7537                                              38       1.0038
                         37        1.36658     238781.1                               37        1.11509     197182.2
                         38       -1.30031    -269826.2                               38       -1.11377    -202507.5
                         92        0.36190       3367.9                               92        0.14531       1447.6

   42       0.8260                                              42       0.9523
                         41        1.18897     284677.0                               41        0.89574     216639.1
                         42       -1.35957    -306940.3                               42       -0.99762    -225201.8
                         93        0.54964      10182.6                               93        0.31192       6040.5

   51       0.9176                                              51       0.5785
                         50        1.04532     269317.6                               50        0.58420     148520.5
                         51       -0.71611    -255158.9                               51       -0.37851    -132954.4

   54       0.8431                                              54       0.5126
                         53        0.50812     210420.1                               53        0.20935      91448.2
                         54       -0.43255    -193281.5                               54       -0.14122     -61904.3

   59       0.7516                                              59       0.4189
                         58        0.02701      15692.2                               58       -0.24771    -141541.9
                         59        0.01562       6349.5                               59        0.32008     168420.3

    1       0.5400                                               1       0.2516
                         65       -0.25368    -187444.9                               65       -0.49026    -365444.1
```

```
SYSTEM STATUS AFTER CYCLE 1900          47.50 HOURS

JUNCTION       HEAD      CHANNEL      VELOCITY        FLOW
 NUMBER        (FT)       NUMBER        (FPS)         (CFS)

  114         1.7588
                              1        2.64364      10815.2

    9         1.5233
                              8       -0.02544       -740.8
                              9       -0.32733     -11290.6
                             66        0.14370       9314.0

   25         1.3131
                             24        0.80204      71472.1
                             25       -0.95953     -75409.4

   34         1.1944
                             33        0.70353     106566.8
                             34       -0.71275    -100037.1
                             85       -0.17520      -8266.2

   38         1.0775
                             37        0.68525     121667.9
                             38       -0.66645    -121551.8
                             92       -0.01156       -117.3

   42         0.9253
                             41        0.47339     114389.9
                             42       -0.47760    -107503.1
                             93       -0.09315      -1814.8

   51         0.2520
                             50        0.00951       2135.9
                             51        0.03733      12893.6

   54         0.1472
                             53       -0.15019     -59937.7
                             54        0.17999      77388.0

   59         0.0437
                             58       -0.44423    -249556.7
                             59        0.52816     273125.6

    1        -0.0360
                             65       -0.62875    -456010.1
```

```
SYSTEM STATUS AFTER CYCLE 1940          48.50 HOURS

JUNCTION       HEAD      CHANNEL      VELOCITY        FLOW
 NUMBER        (FT)       NUMBER        (FPS)         (CFS)

  114         2.2713
                              1        2.61773      10934.0

    9         2.0713
                              8       -0.24787      -7582.9
                              9        0.09498       3412.2
                             66        0.04965       3298.4

   25         1.6343
                             24        0.18401      15111.4
                             25       -0.20216     -16226.3

   34         1.2364
                             33        0.18532      24965.0
                             34       -0.15400     -21661.5
                             85       -0.05896      -2800.2

   38         1.0060
                             37        0.07213      12776.2
                             38       -0.04421      -8392.2
                             92       -0.09340       -981.9

   42         0.7497
                             41       -0.08039     -19206.9
                             42        0.17187      38247.1
                             93       -0.36229      -6814.4

   51        -0.0208
                             50       -0.60879    -151037.9
                             51        0.47375     161336.1

   54        -0.1054
                             53       -0.49274    -193709.9
                             54        0.48423     204990.1

   59        -0.1900
                             58       -0.58174    -322737.2
                             59        0.65067     337415.6

    1        -0.2455
                             65       -0.62844    -452727.6
```

```
SYSTEM STATUS AFTER CYCLE 1980        49.50 HOURS

JUNCTION      HEAD      CHANNEL      VELOCITY       FLOW
 NUMBER       (FT)      NUMBER         (FPS)        (CFS)

   114       2.2724
                            1        2.64600     11052.0

     9       1.9911
                            8       -0.47344    -14455.8
                            9        0.53989     19354.2
                           66       -0.05791     -3842.1

    25       1.5580
                           24       -0.59182    -48361.2
                           25        0.63568     50773.3

    34       1.0956
                           33       -0.63470    -84818.2
                           34        0.61265     85265.3
                           85        0.07647      3543.0

    38       0.8119
                           37       -0.74701   -131238.0
                           38        0.76671    137909.6
                           92       -0.19616     -1867.3

    42       0.5289
                           41       -0.69006   -162341.7
                           42        0.81128    177958.4
                           93       -0.36383     -6522.8

    51      -0.1913
                           50       -1.06603   -262509.2
                           51        0.79686    268951.6

    54      -0.2442
                           53       -0.73876   -287826.4
                           54        0.70203    294491.2

    59      -0.3752
                           58       -0.65769   -362244.2
                           59        0.72925    369741.4

     1      -0.3668
                           65       -0.59645   -420811.6

END OF TWO-DIMENSIONAL EXPLICIT PROGRAM. 2000 CYCLES.
```

```
POTOMAC ESTUARY HYDRAULICS  -  133 JUNCTION NETWORK                                          FEDERAL WATER QUALITY ADMINISTRATION
SIMULATION OF A MEAN TIDAL CONDITION   FLOW = 11,000 CFS AT CHAIN BRIDGE                     NET FLOWS AND HYDRAULIC SUMMARY
POTOMAC ESTUARY HYDRAULICS  -  133 JUNCTIONS  -  139 CHANNELS
MEAN TIDAL CONDITION  FLOW = 11,000 CFS @ CHAIN BRIDGE, 479 CFS @ BLUE PLAINS


******** FROM HYDRAULICS PROGRAM ********      HYDRAULIC CYCLES PER      TIME INTERVAL IN
START CYCLE    STOP CYCLE    TIME INTERVAL         QUALITY CYCLE          QUALITY PROGRAM

  1500           2000         90.  SECONDS              20                   0.50  HOURS



                           * * * * *  FLOW  * * * * *        * *   VELOCITY   * *       * * *  CROSS-SECTIONAL AREA  * * *
CHANNEL      NET FLOW          MIN.               MAX.              MIN.         MAX.          MIN.        MAX.        AVE.
NUMBER        (CFS)           (CFS)              (CFS)             (FPS)        (FPS)       (SQ. FT)    (SQ. FT)    (SQ. FT)
------------------------------------------------------------------------------------------------------------------------------
   1        -10999.57       -11149.80          -10679.30          -3.105       -2.618        3546.1      4199.1      3839.6
   2         10995.54         9088.59           11913.12           0.359        0.472       23871.8     26227.2     24950.3
   3         10999.48         7386.12           12733.67           0.215        0.385       31258.8     34069.4     32545.9
   4         10999.45         5774.93           13514.25           0.229        0.576       21228.3     24707.7     22821.5
   5         10999.39         4100.13           14331.63           0.139        0.574       22110.8     26580.5     24157.1
   6         10999.30         1108.54           15806.57           0.002        0.649       20713.4     26422.9     23325.7
   7         10999.21        -1954.88           17352.27          -0.144        0.724       19600.2     26492.8     22750.6
   8         10999.05        -6262.71           19575.52          -0.299        0.709       22224.5     30755.9     26116.7
   9         11018.38       -25265.95           29768.81          -0.847        0.902       27569.7     36087.7     31447.7
  10         11018.27       -27892.55           31259.22          -0.747        0.772       35033.2     43605.7     38932.2
  11         11018.18       -30004.63           32477.77          -0.779        0.778       35790.5     45204.5     40072.5
  12         11017.96       -34498.26           35161.66          -0.918        0.864       34332.6     44392.1     38908.9
  13         11017.86       -36930.93           36664.15          -1.047        0.979       32989.8     40057.0     36206.2
  14          9149.46       -34992.44           33493.24          -1.176        1.079       27481.8     33357.5     30164.2
  15          8487.20       -37276.02           34264.31          -1.418        1.238       23675.9     30153.0     26636.9
  16         11495.42       -60996.35           54473.60          -1.352        1.154       40847.9     51068.7     45527.7
  17         11495.14       -65117.85           57658.80          -1.215        1.032       48086.1     60664.4     53865.3
  18         11494.86       -69597.81           61291.40          -1.301        1.100       46712.3     61347.9     53460.0
  19         11494.32       -76333.00           66922.50          -1.335        1.141       52136.0     62931.6     57132.5
  20         11494.11       -79164.44           69380.69          -1.407        1.210       52216.3     60829.3     56224.8
  21         11493.91       -81467.06           71421.87          -1.447        1.250       52598.6     60342.7     56226.9
  22         11493.72       -83314.44           73055.75          -1.145        0.994       68733.5     77012.5     72643.2
  23         11492.89       -92572.62           80947.94          -1.205        1.048       71110.7     81491.4     76041.2
  24         11492.43       -96871.44           84860.69          -1.277        1.108       67872.2     82279.6     74765.0
  25         11491.96      -101388.37           89062.37          -1.352        1.163       67716.7     80395.5     73828.7
  26         11491.54      -104905.56           92403.19          -1.514        1.334       63291.9     73462.9     68237.7
  27         11489.99      -111455.50           98516.31          -1.338        1.190       75941.0     88261.0     82000.1
  28         11486.61      -129437.56          114421.37          -1.358        1.200       87047.0    101320.0     94203.0
  29         11485.25      -135953.56          121323.50          -1.274        1.138       99218.8    112188.6    105829.6
  30         11484.31      -141552.25          127435.75          -1.264        1.140      103208.6    118017.1    110918.0
  31         11483.17      -147254.91          133294.75          -1.229        1.121      108826.2    126069.7    117881.1
  32         11482.05      -153550.00          139496.69          -1.184        1.065      120152.2    134546.0    127794.3
  33         11481.27      -158449.91          144361.75          -1.216        1.124      119997.6    134722.7    127888.3
  34         10562.55      -160623.52          146504.81          -1.197        1.104      122018.1    140710.4    132110.1
  35         11157.80      -199581.06          162051.56          -1.215        1.119      149185.9    172985.4    162108.7
```

```
38      11464.56     -253930.06      225962.06      -1.433      1.287      168743.6     182390.4     176271.9
39      11461.46     -264917.31      234717.25      -1.304      1.171      192206.6     209928.1     202012.7
40      11457.88     -279135.81      247453.94      -1.204      1.087      216902.8     240476.1     229952.9
41      11453.96     -292519.69      260831.19      -1.250      1.137      219506.9     242066.4     231972.7
42      11447.09     -314782.25      277349.75      -1.433      1.291      207324.6     225827.0     217527.8
43      11443.12     -330984.94      290443.62      -1.484      1.345      210066.9     227108.5     219439.4
44      11439.26     -338335.06      301610.37      -1.674      1.555      190647.3     203921.5     197373.0
45      11437.62     -341530.62      307318.75      -1.978      1.863      163627.4     173259.1     168619.2
46      11434.53     -344417.50      314890.06      -1.766      1.718      182975.8     195799.2     189167.1
47      11430.55     -359296.06      324759.50      -1.661      1.613      201651.7     218448.1     209421.5
48      11427.65     -373894.50      331741.56      -1.638      1.564      212687.6     229236.4     220147.7
49      11426.64     -373898.06      334192.50      -1.506      1.432      234221.9     249688.2     241091.4
50      11424.41     -372369.00      335211.00      -1.443      1.375      244594.5     260235.9     251476.5
51      11425.79     -368257.25      336068.00      -1.030      1.005      334920.9     362494.7     347033.0
52      11424.60     -369271.00      337359.87      -0.769      0.766      441557.5     481816.5     459240.9
53      11423.94     -369195.37      337567.25      -0.381      0.877      386989.2     421772.4     402277.4
54      11423.98     -372114.06      339678.25      -0.823      0.817      416830.4     456007.4     434090.2
55      11424.02     -388577.06      343278.37      -0.672      0.644      533977.2     583467.6     555849.2
56      11423.93     -400542.06      345185.50      -0.624      0.575      603286.1     653933.1     625771.5
57      11422.38     -484915.31      363445.44      -0.714      0.573      634251.4     687757.1     658147.8
58      11421.90     -509787.81      369470.81      -0.880      0.673      548983.2     592321.8     568541.7
59      11421.72     -535427.25      374143.62      -0.995      0.740      505623.9     546078.6     524130.9
60      11421.62     -595695.81      384092.56      -1.009      0.695      552856.6     598424.0     574018.5
61      11421.50     -626234.31      397281.97      -1.017      0.679      582313.9     626065.2     602901.5
62      11421.67     -640630.06      407642.94      -1.039      0.691      586658.2     628983.1     606806.0
63      11421.35     -660574.25      424573.31      -1.048      0.695      606594.5     645349.7     625273.3
64      11421.81     -683079.75      440608.00      -0.994      0.660      662654.1     698789.6     660276.9
65     -11422.08     -657915.37      701877.62      -0.634      0.946      717121.1     749672.9     733230.6
66         -19.71      -7904.20       14770.57      -0.125      0.249       57235.8      66607.8      61503.1
67         -19.62      -5585.77       10455.00      -0.173      0.345       29513.0      33914.1      31517.4
68         -19.66      -5022.44        9406.62      -0.180      0.359       25612.8      29287.1      27285.3
69         -19.69      -4555.28        8535.27      -0.163      0.326       25607.6      29288.5      27282.1
70         -19.73      -3996.08        7490.16      -0.157      0.315       23335.3      26727.6      24877.7
71         -19.76      -3582.54        6746.53      -0.240      0.463       13539.7      15757.4      14547.2
72         -19.79      -3089.46        5898.50      -0.341      0.698        7667.9       9394.7       8678.0
73         -19.82      -2656.40        5139.41      -0.291      0.597        7727.5       9964.6       8740.5
74         -19.14      -1537.77        2919.16      -0.440      0.968        2467.2       4096.5       3191.7
75         -19.16      -1293.31        2456.51      -0.256      0.524        4293.5       5498.0       4835.9
76         -19.18      -1054.10        2000.19      -0.341      0.716        2421.4       3480.7       2997.4
77           0.10      -1085.89        1805.56      -0.064      0.117       14511.2      18289.4      16230.2
78         462.31      -1166.83        2020.02      -0.045      0.152       13973.4      26510.2      19702.1
79       -3005.27     -15707.95       16656.82      -0.453      0.544       25745.8      37330.4      31044.4
80           0.71      -3521.00        5174.39      -0.144      0.284       13525.3      30694.0      21381.1
81           0.24      -2617.38        3411.17      -0.187      0.335        8355.9      16713.6      12537.7
82           0.64      -5743.80        7926.46      -0.382      0.659        9920.0      18427.7      13946.6
83           0.72      -2460.59        3674.96      -0.180      0.377        7972.7      17496.5      12529.7
84           1.65      -9905.40       15293.65      -0.374      0.672       17815.0      31727.3      24688.7
85         977.31      -6627.29       10478.44      -0.186      0.316       32729.3      47502.6      40706.0
86        -617.05     -26919.77       31724.43      -0.447      0.547       52011.8      65157.2      59131.9
87         934.28     -21763.51       20710.75      -0.302      0.277       62673.9      80922.6      72564.7
88           1.61      -7563.82       14516.74      -0.287      0.623       20171.5      30252.4      25652.8
89           0.73      -1900.81        3663.67      -0.307      0.627        3976.4       8075.0       6198.4
90           1.52      -7751.21       14435.30      -0.195      0.395       35400.3      43496.2      39815.1
91           0.51      -2122.47        3841.54      -0.249      0.484        5908.1      11819.2       9143.3
92           0.68      -2502.73        4460.91      -0.319      0.564        6339.3      10148.4       8431.1
93           2.24      -6924.70       12496.30      -0.417      0.741       14440.9      19536.3      17087.2
94           1.60      -4934.04        6405.21      -0.395      0.704        9875.0      14173.3      12085.4
95           1.77      -5810.11       14356.81      -0.449      0.753       15005.2      21233.5      17911.9
96           1.54     -15455.55       27729.11      -0.427      0.760       31621.7      39281.7      34884.9
```

```
 99      1.69   -59096.10   75739.94   -0.533   0.666   105355.6   119056.4   111326.0
100      1.21   -20265.71   31004.06   -0.638   0.902    24378.1    36160.1    30367.6
101     -0.12   -15637.50   24814.46   -0.344   0.534    43214.9    51023.5    46701.0
102     -0.13   -13367.91   21496.69   -0.346   0.539    35966.0    43586.6    39983.0
103     -0.06   -12281.57   15452.09   -0.395   0.584    28887.0    36789.4    32426.2
104      0.03    -9254.15   13014.53   -0.218   0.298    40161.8    48979.5    44391.0
105    -19.97     -752.98    1465.77   -0.221   0.476     2874.7     3746.5     3243.7
106    -19.96     -541.11    1081.13   -0.175   0.377     2641.0     3555.2     3050.8
107    -19.97     -412.65     781.66   -0.129   0.270     2729.8     3493.1     3071.9
108    -19.98     -308.32     570.54   -0.156   0.346     1474.0     2238.5     1816.5
109    -19.99     -121.24     189.27   -0.131   0.283      532.5     1145.0      806.9
110      0.12    -1458.23    2719.18   -0.078   0.155    16818.5    19604.4    18087.6
111      0.07     -933.43    1555.51   -0.042   0.082    18322.4    21052.0    19565.7
112      0.02     -277.83     518.76   -0.013   0.026    19530.3    22172.8    20733.8
113     -0.45     -804.09    1661.56   -0.816   1.744      822.4     1093.2      944.0
114     -0.77     -305.00     674.73   -0.613   1.406      412.8      565.1      480.2
115      0.75     -118.09     247.00   -0.479   1.054      108.4      321.9      203.3
116      0.43    -3826.92    5390.15   -0.239   0.407    11458.9    18980.4    15019.1
117      0.26    -2196.34    3140.91   -0.130   0.228    11904.6    19952.2    15713.6
118      0.15    -1243.97    1825.40   -0.122   0.224     6851.6    12393.2     9475.0
119      0.07     -554.16     857.46   -0.187   0.451     1225.3     4253.5     2657.7
120      0.89    -5729.02    9112.27   -0.207   0.363    22079.4    31204.8    26569.6
121      0.66    -4218.37    6778.62   -0.153   0.272    21911.0    31198.6    26475.6
122      0.24    -1550.15    2637.15   -0.198   0.396     5002.0     9606.6     7261.5
123      0.13     -757.40    1409.04   -0.195   0.458     1757.9     5466.6     3575.9
124      0.04     -277.49     562.85   -0.176   0.432      848.3     2009.5     1414.4
125      0.28    -1727.19    2760.45   -0.117   0.218    10512.1    17412.0    13901.5
126      0.11     -653.20    1072.54   -0.118   0.228     3835.0     6602.9     5194.2
127      0.03     -155.80     278.96   -0.160   0.389      440.6     1366.7      894.5
128    316.17    -1063.57    1890.12   -0.047   0.000    23304.7    31538.6    27769.1
129      0.24     -911.47    1558.30   -0.406   0.677     1540.8     2872.4     2227.3
130   -315.67    -2725.36    1970.29   -0.276   0.269     5709.3    10516.9     8320.6
131   9120.65   -31914.15   31371.16   -1.264   1.176    23512.1    28620.6    25838.8
132   1896.94    -7167.11    6995.57   -0.900   0.764     7252.7     9807.7     8416.4
133   -746.01    -2096.61    2842.57   -0.243   0.233    10005.2    14674.2    12132.5
134  -9866.43   -35077.11   35921.55   -1.045   1.118    30133.2    35772.9    32704.4
135   1629.98    -5132.69    6295.28   -0.803   0.699     5497.2     9294.1     7223.1
136    716.86    -2479.03    2605.64   -0.224   0.196     8285.3    15874.0    11746.7
137      0.07     -645.83    1061.78   -0.091   0.159     4598.9     8815.1     6523.5
138  -2346.49   -10004.98    9798.03   -0.670   0.785    10953.1    15988.9    13253.0
139   3308.49   -13310.98   12799.94   -0.819   0.705    13759.1    20003.9    16613.6
```

** SUMMARY OF JUNCTION HEADS **

JUNCTION	MINIMUM HEAD (FT)	CYCLE OF OCCURENCE	MAXIMUM HEAD (FT)	CYCLE OF OCCURENCE	AVERAGE HEAD (FT)	TIDAL RANGE (FT)
1	-0.38	1998	1.04	1703	0.33	1.42
2	-0.82	1786	2.13	1958	0.53	2.95
3	-0.82	1786	2.12	1958	0.53	2.94
4	-0.82	1785	2.12	1956	0.52	2.94
5	-0.82	1785	2.12	1956	0.52	2.96
6	-0.83	1784	2.11	1958	0.52	2.94
7	-0.83	1782	2.10	1958	0.51	2.93
8	-0.84	1780	2.09	1958	0.50	2.93
9	-0.85	1777	2.07	1958	0.48	2.93
10	-0.85	1774	2.06	1958	0.47	2.91
11	-0.85	1774	2.05	1957	0.47	2.90
12	-0.84	1772	2.04	1957	0.47	2.88
13	-0.84	1770	2.02	1957	0.46	2.86
14	-0.83	1766	1.98	1956	0.45	2.81
15	-0.82	1764	1.96	1956	0.45	2.79
16	-0.82	1760	1.94	1955	0.44	2.75
17	-0.81	1757	1.91	1955	0.44	2.72
18	-0.80	1754	1.87	1954	0.43	2.67
19	-0.79	1752	1.85	1954	0.43	2.65
20	-0.78	1748	1.81	1954	0.42	2.60
21	-0.78	1747	1.79	1954	0.42	2.56
22	-0.76	1744	1.75	1954	0.42	2.51
23	-0.76	1743	1.73	1954	0.42	2.49
24	-0.75	1741	1.69	1954	0.42	2.44
25	-0.74	1738	1.66	1954	0.41	2.39
26	-0.73	1735	1.62	1953	0.41	2.35
27	-0.71	1732	1.58	1952	0.41	2.29
28	-0.70	1728	1.51	1950	0.40	2.21
29	-0.68	1723	1.44	1947	0.40	2.12
30	-0.66	1720	1.40	1945	0.40	2.05
31	-0.64	1716	1.34	1942	0.39	1.98
32	-0.63	1713	1.30	1939	0.39	1.93
33	-0.62	1711	1.26	1936	0.39	1.88
34	-0.61	1709	1.24	1933	0.39	1.85
35	-0.59	1705	1.21	1925	0.36	1.80
36	-0.57	1701	1.17	1916	0.38	1.74
37	-0.53	1695	1.13	1909	0.38	1.66
38	-0.49	1689	1.08	1900	0.36	1.56
39	-0.45	1683	1.04	1893	0.37	1.50
40	-0.42	1677	1.01	1885	0.37	1.43
41	-0.39	1672	0.98	1879	0.37	1.38
42	-0.37	1666	0.96	1873	0.37	1.33
43	-0.36	1657	0.93	1863	0.36	1.27
44	-0.31	1649	0.91	1847	0.36	1.21
45	-0.28	1640	0.90	1870	0.36	1.18
46	-0.26	1624	0.97	1796	0.35	1.23
47	-0.26	1613	1.03	1792	0.35	1.23
48	-0.28	1597	1.09	1784	0.34	1.37
49	-0.30	1592	1.13	1765	0.34	1.44

52	-0.36	1553	1.21	1751	0.33	1.57
53	-0.37	1548	1.23	1749	0.33	1.59
54	-0.38	1544	1.24	1747	0.33	1.61
55	-0.39	1541	1.24	1746	0.33	1.63
56	-0.39	1537	1.24	1744	0.33	1.63
57	-0.39	1533	1.23	1742	0.33	1.63
58	-0.39	1530	1.22	1740	0.33	1.61
59	-0.40	1524	1.20	1736	0.33	1.60
60	-0.40	1519	1.18	1732	0.33	1.58
61	-0.40	1513	1.16	1727	0.33	1.56
62	-0.40	1510	1.14	1724	0.33	1.54
63	-0.40	1507	1.12	1720	0.33	1.52
64	-0.40	1504	1.10	1716	0.33	1.49
65	-0.39	1502	1.09	1712	0.33	1.47
66	-0.85	1778	2.09	1958	0.48	2.93
67	-0.86	1778	2.09	1958	0.48	2.94
68	-0.86	1778	2.09	1958	0.48	2.94
69	-0.86	1779	2.09	1956	0.48	2.95
70	-0.86	1779	2.09	1958	0.48	2.95
71	-0.86	1780	2.10	1958	0.48	2.96
72	-0.87	1781	2.11	1958	0.48	2.98
73	-0.87	1781	2.12	1958	0.48	2.99
74	-0.88	1783	2.13	1958	0.48	3.01
75	-0.88	1784	2.14	1957	0.47	3.02
76	-0.89	1785	2.15	1957	0.47	3.03
77	-0.89	1785	2.15	1956	0.47	3.04
78	-0.85	1772	2.04	1957	0.47	2.88
79	-0.82	1764	1.96	1956	0.45	2.79
80	-0.82	1761	1.94	1955	0.44	2.77
81	-0.82	1761	1.94	1955	0.44	2.76
82	-0.80	1753	1.66	1954	0.43	2.66
83	-0.77	1746	1.73	1956	0.42	2.53
84	-0.72	1734	1.58	1953	0.41	2.31
85	-0.72	1737	1.55	1952	0.40	2.27
86	-0.62	1711	1.23	1929	0.38	1.85
87	-0.61	1709	1.22	1928	0.38	1.83
88	-0.65	1718	1.24	1916	0.38	1.89
89	-0.59	1715	1.18	1910	0.37	1.77
90	-0.59	1704	1.19	1917	0.38	1.78
91	-0.55	1703	1.17	1910	0.37	1.69
92	-0.52	1703	1.09	1896	0.37	1.61
93	-0.39	1701	1.05	1892	0.34	1.44
94	-0.32	1695	1.00	1886	0.34	1.32
95	-0.27	1648	1.05	1874	0.32	1.33
96	-0.30	1619	1.24	1791	0.32	1.54
97	-0.38	1558	1.24	1749	0.33	1.63
98	-0.40	1553	1.36	1747	0.32	1.74
99	-0.42	1546	1.32	1748	0.33	1.74
100	-0.43	1588	1.36	1793	0.33	1.80
101	-0.41	1515	1.28	1731	0.33	1.69
102	-0.42	1509	1.26	1726	0.33	1.67
103	-0.42	1519	1.28	1734	0.32	1.72
104	-0.42	1503	1.16	1719	0.33	1.55
105	-0.90	1786	2.16	1956	0.47	3.05
106	-0.90	1787	2.16	1955	0.47	3.06
107	-0.90	1787	2.16	1955	0.47	3.06
108	-0.90	1788	2.16	1955	0.47	3.06
109	-0.86	1778	2.08	1958	0.48	2.93
110	-0.86	1778	2.09	1958	0.48	2.94

113	-0.90	1789	2.15	1960	0.45	3.07
114	-0.47	1788	2.33	1958	0.80	2.80
115	-0.78	1747	1.74	1958	0.41	2.51
116	-0.78	1748	1.74	1959	0.41	2.52
117	-0.79	1748	1.74	1959	0.41	2.52
118	-0.78	1751	1.74	1959	0.41	2.53
119	-0.73	1739	1.54	1953	0.39	2.29
120	-0.73	1740	1.56	1953	0.39	2.30
121	-0.74	1742	1.57	1953	0.39	2.31
122	-0.74	1747	1.57	1953	0.39	2.32
123	-0.75	1750	1.58	1953	0.38	2.33
124	-0.74	1740	1.57	1953	0.39	2.30
125	-0.76	1741	1.57	1953	0.39	2.31
126	-0.75	1746	1.57	1953	0.39	2.32
127	-0.61	1710	1.22	1929	0.36	1.83
128	-0.53	1743	1.25	1928	0.37	1.78
129	-0.94	1769	2.01	1957	0.46	2.65
130	-0.83	1767	2.00	1957	0.46	2.83
131	-0.83	1767	2.00	1957	0.46	2.83
132	-0.93	1766	1.98	1956	0.45	2.81
133	-0.83	1766	1.98	1956	0.45	2.61

```
        ****************************    CHECK HYDRAULIC EXTRACT TAPE    ******************************

CYCLE                 HEADS AT JUNCTIONS                                        FLOWS IN CHANNELS

            1       50       30       10      114             65          50          30          10           1
------------------------------------------------------------------------------------------------------------------------

 1500     -0.38    -0.22     1.10     1.77     2.09      -369975.06   308512.62   117554.69    28221.80   -11127.75
 1520     -0.35    -0.27     0.99     1.50     1.84      -305939.19   326483.12   127435.75    30703.39   -11141.34
 1540     -0.26    -0.31     0.67     1.19     1.55      -205830.56   335211.00   126903.00    31259.22   -11145.80
 1560     -0.11    -0.32     0.45     0.38     1.24       -62132.00   330852.25   120009.81    30105.39   -11139.68
 1580      0.09    -0.32     0.25     0.59     0.96       119604.87   307609.75   110193.56    28198.05   -11126.39
 1600      0.33    -0.28     0.06     0.32     0.71       317767.69   262469.00    99655.06    26208.69   -11111.31
 1620      0.57    -0.17    -0.12     0.09     0.48       501782.75   191876.00    89452.75    24251.93   -11096.89
 1640      0.77     0.01    -0.28    -0.11     0.29       639122.75    91972.56    80030.50    22394.70   -11083.16
 1660      0.92     0.28    -0.42    -0.20     0.12       701877.62   -29529.58    71108.25    20756.23   -11070.96
 1680      1.01     0.57    -0.56    -0.44    -0.02       680853.44  -152829.75    61509.80    19413.83   -11060.94
 1700      1.04     0.82    -0.62    -0.54    -0.15       586921.06  -256139.44    49216.10    18316.49   -11052.90
 1720      1.03     1.02    -0.64    -0.68    -0.25       446006.31  -327601.12    30599.06    17253.51   -11045.91
 1740      0.98     1.14    -0.61    -0.77    -0.35       288337.37  -366712.19    -2470.06    15807.61   -11037.40
 1760      0.91     1.17    -0.40    -0.93    -0.42       130054.12  -372369.00   -52539.85    13267.95   -11023.12
 1780      0.91     1.14    -0.09    -0.85    -0.47       -14866.33  -346869.50   -98551.00     7913.70   -10995.39
 1800      0.70     1.06     0.24    -0.75    -0.46      -134940.31  -297779.81  -127670.69    -5527.48   -10926.25
 1820      0.56     0.96     0.51    -0.42    -0.30      -235223.00  -240382.75  -141221.06   -22355.21   -10731.23
 1840      0.41     0.78     0.75     0.06     0.25      -324212.37  -180666.62  -141552.25   -27892.56   -10679.30
 1860      0.25     0.42     0.95     0.60     0.90      -399830.06  -113544.06  -131107.31   -22561.64   -10781.46
 1880      0.10     0.45     1.11     1.12     1.34      -445566.06   -40237.24  -112568.06   -15946.73   -10791.80
 1900     -0.04     0.30     1.24     1.51     1.76      -457915.37    37000.03   -85091.62    -9526.12   -10846.22
 1920     -0.15     0.16     1.34     1.83     2.07      -455655.62   114271.44   -47122.91    -1482.03   -10897.69
 1940     -0.25     0.03     1.39     2.00     2.27      -446998.00   183897.19     -223.56     7285.52   -10971.73
 1960     -0.32    -0.07     1.37     2.04     2.33      -430687.25   239685.50    50869.50    15955.29   -11024.73
 1980     -0.37    -0.15     1.28     1.97     2.27      -408008.75   280556.69    92737.19    23446.21   -11085.89
```

4.4 SAMPLE DYNQUAL INPUT/OUTPUT

4.4.1 3 CONSERVATIVE CONSTITUENTS

-- data deck listing --

```
DYNQUAL - SAMPLE RUN 1  -  THIS RUN SIMULATES THE MOVEMENT OF 3 CONSERVATIVE
                           PARAMETERS (DYES) THROUGHOUT THE POTOMAC ESTUARY
  133  139 1500 2000   20
INDEPENDENT CONTROL DATA - RUN 1
 1500  500  999  999   25
    3    0    4    4
      30.0       6.00
TABULAR OUTPUT CONTROL - RUN 1
    0    0
    1    1
  125  200    1
    0
PLOTTING OUTPUT CONTROL - RUN 1
    5    0    1
    0    0
    5    1  500   25    1    0    0
   15    1  500   25    0    1    0
  130    1  500   25    0    1    0
  130  450  500    1    0    1    0
  130  120  175    1    0    0    1
  2.5   0.   .5   0.   .4   0.
QUALITY COEFFICIENTS - RUN 1
        0.         1.         1.         1.
        0.       1.00       100. DYE1
        0.       1.00       100. DYE2
        0.       1.00       100. DYE3
DIFFUSION CONSTANTS - RUN 1
    1
         1       139        25.
UPTAKE / REGENERATION RATES - RUN 1
    1
         1       133        0.         0.         0.         0.         0.
DECAY RATES - RUN 1
    1
         1       133        0.         0.         0.         0.         0.         0.
WASTEWATER INPUTS - RUN 1
    1    1    0
CONSTANT INPUTS
       131      -450.       0.         1.         0.
VARIABLE INPUTS
   131    3
       125         0.       0.         0.         0.
        25      -450.       0.         0.         2.
       350         0.       0.         0.         0.
UPPER BOUNDARY CONDITIONS - RUN 1
    1
       500    -1500.        2.         0.         0.
INITIAL CONDITIONS - RUN 1
         1       133        .1         .1         .1
SEAWARD BOUNDARY CONDITIONS - RUN 1
    1    1    1
   0.
   0.
   0.
```

-- output listing --

```
POTOMAC ESTUARY HYDRAULICS  -  133 JUNCTION NETWORK                                                     ENVIRONMENTAL PROTECTION AGENCY
FLOW = 1500 CFS AT CHAIN BRIDGE, 450 CFS AT BLUE PLAINS, 0 AT OTHER STP'S                                 DYNAMIC ESTUARY MODEL
DYNQUAL - SAMPLE RUN 1  -  THIS RUN SIMULATES THE MOVEMENT OF 3 CONSERVATIVE
                           PARAMETERS (DYES) THROUGHOUT THE POTOMAC ESTUARY

 ***********************   HYDRAULIC CONTROL DATA   ***********************

 FIRST CYCLE ON     LAST CYCLE  ON     BEGIN READING TAPE      HYDRAULIC
 HYDRAULIC TAPE     HYDRAULIC TAPE          AT CYCLE        TIME STEP (SEC.)
    (NSTART)           (NSTOP)              (HYDCYC)             (DELT)

      1500              2000                  1500                90.00

 *********************************************   QUALITY CONTROL DATA   *********************************************

            NUMBER OF        NUTRIENT LIMITATION       D.O. SUMMARY           QUALITY            QUALITY STEPS
         QUALITY CYCLES    SUMMARY BEGINS AT CYCLE   BEGINS AT CYCLE     TIME STEP (HRS)     PER TIDAL PERIOD
             (NQCYC)               (NUTCYC)              (NDOCYC)            (DELTQ1)              (NSPEC)

               500                   999                   900                 0.50                  25

 NUMBER OF                            STARTING TIME      TIME OF      TIME OF      D.O. SATURATION
 CONSTITUENTS        TEMPERATURE       FOR THIS RUN       SUNRISE       SUNSET        AT 30.00  C
  (NUMCON)              (TEMP)            (STIME)          (TSRISE)      (TSSET)          (CSAT)

      3                 30.00              6.00             0.0          0.0            0.0


 CONSTITUENT         CONSTITUENT        BACKGROUND           TEMPERATURE
   NUMBER               NAME           CONCENTRATION      CORRECTION FACTOR
                       (CNAME)            (BACKC)              (THETA)

      1                 DYE1                0.0                 1.000
      2                 DYE2                0.0                 1.000
      3                 DYE3                0.0                 1.000

                                                                          PERCENT OF DECAYED ALGAE
CHLOROPHYLL/NITROGEN     CHLOROPHYLL/PHOSPHOROUS     CHLOROPHYLL/CARBON     WHICH IS BIO-DEGRADABLE
      (CHLNIT)                  (CHLPHO)                  (CHLCAR)                  (PERCD)

        1.00                      1.00                      1.00                      0.0

 CONSTITUENT CONCENTRATIONS IN ADVECTED WATER ARE COMPUTED USING THE 1/4 POINT CONCENTRATION  (MIX=4)
```

```
*****************************************  SUMMARY OF HYDRAULIC INPUTS  *****************************************

        CROSS-SECTIONAL AREA AND HYDRAULIC RADIUS OF CHANNELS AND JUNCTION HEADS ARE AT MEAN TIDE

*******************************  CHANNEL DATA  *********************************     *************** JUNCTION DATA  *************

CHAN  LENGTH   WIDTH  CS-AREA  MANNING   DIFF   NET FLOW   HYD. RAD.  JUNC. AT ENDS  |  JUNC  INFLOW  HEAD    CHANNELS INTO JUNCTION
-------------------------------------------------------------------------------------|-------------------------------------------
  1    7614.    224.    3783.   0.020    5.74  -1499.97      15.9        2    114    |    1      0.0  0.33    65    0    0    0    0
  2    7074.    800.   24853.   0.020    6.36   1499.98      31.1        2      3    |    2      0.0  0.40     1    2    0    0    0
  3    2551.    955.   32431.   0.020   15.78   1499.99      34.0        3      4    |    3      0.0  0.40     2    3    0    0    0
  4    4065.   1183.   22681.   0.020   11.07   1500.01      19.2        4      5    |    4      0.0  0.40     3    4    0    0    0
  5    3749.   1521.   23982.   0.020   12.09   1500.02      15.8        5      6    |    5      0.0  0.40     4    5    0    0    0
  6    5597.   1945.   23115.   0.020    8.04   1499.91      11.9        6      7    |    6      0.0  0.40     5    6    0    0    0
  7    3550.   2350.   22518.   0.020   12.53   1499.87       9.6        7      8    |    7      0.0  0.40     6    7    0    0    0
  8    5432.   2912.   25863.   0.020    9.27   1499.83       8.9        8      9    |    8      0.0  0.40     7    8    0    0    0
  9    4063.   2920.   31228.   0.020   11.07   1519.87      10.7        9     10    |    9      0.0  0.40     8    9   64    0    0
 10    1690.   2953.   38725.   0.017   24.63   1519.89      13.1       10     11    |   10      0.0  0.40     9   10    0    0    0
 11    3696.   3258.   39852.   0.017   12.18   1519.86      12.2       11     12    |   11      0.0  0.40    10   11    0    0    0
 12    3010.   3507.   38684.   0.017   14.95   1519.92      11.0       12     13    |   12      0.0  0.40    11   12   77    0    0
 13    2270.   2475.   36055.   0.017   19.62   1519.87      14.6       13    129    |   13      0.0  0.40    12   13    0    0    0
 14    3690.   2100.   30055.   0.017   12.20   1172.88      14.3       14     15    |   14      0.0  0.40    14  134  135    0    0
 15    4180.   2340.   26529.   0.017   10.77   1383.42      11.3       15     16    |   15      0.0  0.40    14   15   78    0    0
 16    3655.   3738.   45378.   0.017   11.67   1969.85      12.1       16     17    |   16      0.0  0.40    15   16   79   80    0
 17    6177.   4671.   53702.   0.017    7.29   1969.84      11.5       17     18    |   17      0.0  0.40    16   17    0    0    0
 18    2640.   5506.   53294.   0.017   17.05   1969.83       9.7       18     19    |   18      0.0  0.40    17   18    0    0    0
 19    5366.   4117.   57024.   0.017    8.35   1969.79      13.9       19     20    |   19      0.0  0.40    18   19   81    0    0
 20    3276.   3337.   56147.   0.017   13.74   1969.76      16.8       20     21    |   20      0.0  0.40    19   20    0    0    0
 21    5280.   3052.   56163.   0.017    8.52   1969.73      18.4       21     22    |   21      0.0  0.40    20   21    0    0    0
 22    3007.   3319.   72579.   0.017   14.94   1969.72      21.9       22     23    |   22      0.0  0.40    21   22    0    0    0
 23    5227.   4221.   75968.   0.017    8.61   1969.59      18.0       23     24    |   23      0.0  0.40    22   23   82    0    0
 24    5069.   5967.   74674.   0.017    8.69   1969.51      12.5       24     25    |   24      0.0  0.40    23   24    0    0    0
 25    5016.   5355.   73761.   0.017    8.97   1969.40      13.8       25     26    |   25      0.0  0.40    24   25    0    0    0
 26    4605.   4388.   68192.   0.017    9.57   1969.33      15.5       26     27    |   26      0.0  0.40    25   26    0    0    0
 27    8765.   5469.   81964.   0.017    5.13   1969.14      15.0       27     28    |   27      0.0  0.40    26   27   83    0    0
 28    9081.   6604.   94185.   0.017    4.94   1967.33      14.3       28     29    |   28      0.0  0.40    27   28   84    0    0
 29    6706.   6223.  105827.   0.017    6.71   1966.81      17.0       29     30    |   29      0.0  0.40    28   29    0    0    0
 30    8342.   7369.  110934.   0.017    5.39   1966.25      15.2       30     31    |   30      0.0  0.40    29   30    0    0    0
 31    5597.   8633.  117920.   0.017    8.04   1965.73      17.3       31     32    |   31      0.0  0.40    30   31    0    0    0
 32    5650.   7562.  127836.   0.017    7.96   1965.26      16.9       32     33    |   32      0.0  0.39    31   32    0    0    0
 33    4065.   7908.  127938.   0.017   11.07   1965.07      16.2       33     34    |   33      0.0  0.39    32   33    0    0    0
 34    6706.  10273.  132188.   0.017    6.71   2278.61      12.9       34     35    |   34      0.0  0.39    33   34   85    0    0
 35    8026.  13474.  162228.   0.014    5.61   1725.22      12.0       35     36    |   35      0.0  0.39    34   35   86    0    0
 36   10507.  10224.  183741.   0.014    4.28   1960.65      18.0       36     37    |   36      0.0  0.39    35   36   89   90  130
 37   13464.   7824.  171952.   0.014    3.34   1959.69      22.0       37     38    |   37      0.0  0.39    36   37   91    0    0
 38    9715.   8934.  176359.   0.014    4.63   1959.03      19.7       38     39    |   38      0.0  0.39    37   38   92    0    0
 39   12144.  12130.  202134.   0.014    3.71   1958.33      16.7       39     40    |   39      0.0  0.38    38   39    0    0    0
 40   10676.  16607.  230127.   0.014    4.16   1956.80      13.7       40     41    |   40      0.0  0.38    39   40    0    0    0
 41   11246.  16701.  232151.   0.014    4.09   1954.86      13.9       41     42    |   41      0.0  0.38    40   41    0    0    0
 42   12460.  14316.  217678.   0.014    3.61   1953.03      15.2       42     43    |   42      0.0  0.38    41   42   93    0    0
 43   12330.  13602.  219580.   0.014    3.51   1951.35      15.9       43     44    |   43      0.0  0.37    42   43   94    0    0
 44   10824.  11116.  197979.   0.014    4.16   1949.82      17.8       44     45    |   44      0.0  0.37    43   44    0    0    0
 45   17529.   8076.  166689.   0.014    2.57   1949.09      20.9       45     46    |   45      0.0  0.37    44   45    0    0    0
 46   10560.  10217.  199254.   0.014    4.24   1947.62      16.5       46     47    |   46      0.0  0.36    45   46    0    0    0
 47   14244.  12765.  209527.   0.014    3.16   1945.70      15.6       47     48    |   47      0.0  0.36    46   47   95    0    0
```

```
        9620.  10325.  251552.  0.014   4.58   1943.40   24.4    50   51  I   50    0.0  0.34    49   50    0    0  0
        6441.  17716.  347154.  0.014   6.99   1943.13   19.6    51   52  I   51    0.0  0.34    50   51    0    0  0
  52   10560.  25490.  459612.  0.014   4.26   1942.93   18.0    52   53  I   52    0.0  0.34    51   52   97    0  0
  53    9451.  21717.  402421.  0.014   4.74   1942.44   18.5    53   54  I   53    0.0  0.34    52   53    0    0  0
  54    6611.  24187.  434251.  0.014   6.61   1941.68   18.0    54   55  I   54    0.0  0.34    53   54    0    0  0
  55   10665.  39413.  556047.  0.014   4.22   1942.11   13.3    55   56  I   55    0.0  0.34    54   55   98    0  0
  56   10137.  31129.  625965.  0.014   4.44   1942.17   20.1    56   57  I   56    0.0  0.34    55   56    0    0  0
  57    8712.  33034.  658347.  0.014   5.17   1940.47   19.9    57   58  I   57    0.0  0.34    56   57   99    0  0
  58   12302.  27018.  568689.  0.014   3.65   1940.15   21.0    58   59  I   58    0.0  0.34    57   58    0    0  0
  59   10612.  25500.  524251.  0.014   4.24   1940.20   20.6    59   60  I   59    0.0  0.34    58   59    0    0  0
  60   11615.  29075.  574128.  0.014   3.67   1939.67   19.7    60   61  I   60    0.0  0.33    59   60  101  103  0
  61    6705.  28658.  602987.  0.014   6.71   1939.23   21.3    61   62  I   61    0.0  0.33    60   61  102    0  0
  62    8712.  27676.  606865.  0.014   5.17   1939.51   21.9    62   63  I   62    0.0  0.33    61   62    0    0  0
  63    8659.  25725.  625313.  0.014   5.20   1939.42   24.3    63   64  I   63    0.0  0.33    62   63  104    0  0
  64    8659.  24384.  680297.  0.014   5.20   1939.30   27.9    64   65  I   64    0.0  0.33    63   64    0    0  0
  65   16194.  22510.  733238.  0.014   2.79  -1939.18   32.6     1   65  I   65    0.0  0.33    64   65    0    0  0
  66    2600.   3200.   61256.  0.024  17.31    -19.91   19.1     9   66  I   66    0.0  0.40    66   67  110    0  0
  67    2660.   1500.   31398.  0.024  17.05    -20.04   20.9    66   67  I   67    0.0  0.40    67   68    0    0  0
  68    2380.   1250.   27185.  0.024  18.91    -20.04   21.7    67   68  I   68    0.0  0.40    68   69    0    0  0
  69    2510.   1250.   27182.  0.024  17.93    -20.03   21.7    68   69  I   69    0.0  0.40    69   70    0    0  0
  70    2640.   1150.   24786.  0.024  17.05    -20.03   21.6    69   70  I   70    0.0  0.40    70   71    0    0  0
  71    3035.    750.   14488.  0.024  14.83    -20.02   19.3    70   71  I   71    0.0  0.40    71   72    0    0  0
  72    3450.    750.    8618.  0.024  13.12    -20.02   11.5    71   72  I   72    0.0  0.40    72   73    0    0  0
  73    3300.    750.    8681.  0.024  13.64    -20.01   11.6    72   73  I   73    0.0  0.40    73   74  113    0  0
  74    3035.    550.    3149.  0.026  14.63    -19.49    5.7    73   74  I   74    0.0  0.40    74   75    0    0  0
  75    3430.    400.    4805.  0.026  13.12    -19.67   12.0    74   75  I   75    0.0  0.40    75   76    0    0  0
  76    3565.    350.    2670.  0.026  12.62    -19.69    9.2    75   76  I   76    0.0  0.40    76  105  115    0  0
  77    4630.   1311.   16144.  0.022   9.32      0.01   12.3    12   78  I   77    0.0  0.40   105  106    0    0  0
  78    2160.   4500.   19478.  0.020  21.43   -210.55    4.3    15   79  I   78    0.0  0.40    77    0    0    0  0
  79    3450.   4200.   30863.  0.020  13.04   -586.20    7.3    16   80  I   79    0.0  0.40    78  136  139    0  0
  80    3405.   6231.   21119.  0.022  13.22      0.03    3.4    16   81  I   80    0.0  0.40    79  139    0    0  0
  81    5550.   2922.   12456.  0.022   8.11      0.04    4.3    19   82  I   81    0.0  0.40    80    0    0    0  0
  82    7700.   3412.   13886.  0.022  12.16      0.12    4.1    23   83  I   82    0.0  0.40    81    0    0    0  0
  83    4320.   4140.   12598.  0.022  10.42      0.08    3.0    27   84  I   83    0.0  0.40    82  116    0    0  0
  84   10530.   6214.   24678.  0.022   4.27      0.56    4.0    26   85  I   84    0.0  0.40    83    0    0    0  0
  85    6251.   8000.   40765.  0.022   7.20   -314.21    5.1    34   86  I   85    0.0  0.40    84  120    0    0  0
  86   10030.   7250.   59191.  0.022   4.50    552.80    8.2    35   87  I   86    0.0  0.39    85   87   68    0  0
  87    7350.   9230.   72642.  0.022   5.12   -315.33    7.3    86   87  I   87    0.0  0.39    86   87  128    0  0
  88   12855.   5401.   25708.  0.022   3.50      0.54    4.8    86   88  I   88    0.0  0.39    88    0    0    0  0
  89    8190.   2347.    6279.  0.022   5.49      0.15    2.7    36   89  I   89    0.0  0.39    89    0    0    0  0
  90   14200.   4601.   39850.  0.022   2.78      0.57    8.7    36   90  I   90    0.0  0.39    90    0    0    0  0
  91    6450.   3531.    9184.  0.022   6.53      0.17    2.0    37   91  I   91    0.0  0.39    91    0    0    0  0
  92   12180.   2408.    8465.  0.022   3.69      0.24    3.5    38   92  I   92    0.0  0.38    92    0    0    0  0
  93   26700.   3786.   17163.  0.022   1.69      0.93    4.5    42   93  I   93    0.0  0.37    93    0    0    0  0
  94   27410.   3635.   12156.  0.022   2.01      0.65    3.5    43   94  I   94    0.0  0.37    94    0    0    0  0
  95   24610.   5027.   17999.  0.022   1.81      0.88    3.6    47   95  I   95    0.0  0.35    95    0    0    0  0
  96   30900.   5303.   34955.  0.022   1.46      0.60    5.6    46   96  I   96    0.0  0.34    96    0    0    0  0
  97   17680.   4200.   23655.  0.022   2.63      0.78    5.6    52   97  I   97    0.0  0.34    97    0    0    0  0
  98   19950.   6037.   20912.  0.022   2.26      0.17    5.2    55   98  I   98    0.0  0.33    98    0    0    0  0
  99   36630.   8160.  111387.  0.022   1.22      1.70   13.7    57   99  I   99    0.0  0.34    99  100    0    0  0
 100   24650.   8160.   30444.  0.022   1.83      0.72    3.7    99  100  I  100    0.0  0.34   100    0    0    0  0
 101   32250.   4778.   46728.  0.022   1.40      0.10    9.6    60  101  I  101    0.0  0.33   101    0    0    0  0
 102   33000.   4100.   40002.  0.022   1.36      0.00    9.8    61  102  I  102    0.0  0.33   102    0    0    0  0
 103   26310.   4792.   32453.  0.022   1.71      0.10    6.8    60  103  I  103    0.0  0.33   103    0    0    0  0
 104   16140.   5740.   44494.  0.022   2.79     -0.07    7.7    63  104  I  104    0.0  0.33   104    0    0    0  0
 105    3301.    300.    3221.  0.028  13.64    -19.99   10.7    76   77  I  105    0.0  0.40   106  107    0    0  0
 106    3165.    300.    3028.  0.028  14.22    -20.00   10.1    77  105  I  106    0.0  0.40   107  106    0    0  0
 107    2770.    250.    3053.  0.029  14.25    -20.00   12.2   105  106  I  107    0.0  0.40   108  109    0    0  0
 108    2640.    210.    1797.  0.029  17.05    -20.00    7.2   106  107  I  108  -20.0  0.40   109    0    0    0  0
 111   3400.   930.  19491.  0.024  13.24      0.01   21.0     109   110   I  111      0.0  0.40   112    0    0    0   0
 112   3500.   900.  20662.  0.024  12.66     -0.00   23.0     110   111   I  112      0.0  0.39   113  114    0    0   0
 113   3200.    50.    937.  0.035  14.06     -0.30   10.4      73   112   I  113      0.0  0.38   114  115    0    0   0
 114   4200.    50.    477.  0.035  10.71     -0.31    9.5     112   113   I  114  -1500.0  0.41     1    0    0    0   0
 115   2700.    70.    198.  0.035  15.67      0.31    2.8      76   113   I  115      0.0  0.40   116  117    0    0   0
 116   3350.  3000.  14969.  0.035  13.43      0.06    5.0      63   115   I  116      0.0  0.40   117  118    0    0   0
 117   2650.  3200.  15663.  0.035  15.79      0.06    4.9     115   116   I  117      0.0  0.40   118  119    0    0   0
 118   1850.  2200.   9440.  0.035  24.32      0.04    4.3     116   117   I  118      0.0  0.40   119    0    0    0   0
 119   1450.  1200.   2640.  0.035  30.41      0.02    2.2     117   118   I  119      0.0  0.40   120  121    0    0   0
 120   6300.  4000.  26574.  0.035  10.47      0.24    6.6      85   119   I  120      0.0  0.40   121  122  125    0   0
 121   2560.  4050.  26492.  0.035  18.00      0.17    6.5     119   120   I  121      0.0  0.39   122  123    0    0   0
 122   3000.  2000.   7266.  0.035  15.00      0.06    3.6     120   121   I  122      0.0  0.39   123  124    0    0   0
 123   2400.  1600.   3582.  0.035  20.45      0.04    2.2     121   122   I  123      0.0  0.39   124    0    0    0   0
 124   2000.   500.   1417.  0.035  22.50      0.01    2.3     122   123   I  124      0.0  0.40   125  126    0    0   0
 125   2750.  3000.  13907.  0.035  16.36      0.08    4.6     120   124   I  125      0.0  0.40   126  127    0    0   0
 126   3600.  1200.   5197.  0.035  15.00      0.04    4.3     124   125   I  126      0.0  0.39   127    0    0    0   0
 127   2600.   400.    896.  0.035  17.31      0.01    2.2     125   126   I  127      0.0  0.39   128  129  130    0   0
 128   5300.  4500.  27806.  0.035   8.49    237.15    6.2      87   127   I  128      0.0  0.40   129    0    0    0   0
 129   5000.   750.   2241.  0.035   5.00      0.10    3.0     127   128   I  129      0.0  0.40    13  131  132    0   0
 130  12500.  2700.   8344.  0.035   3.60   -236.97    3.1      36   127   I  130      0.0  0.40   131  133  134    0   0
 131   2490.  1800.  25734.  0.017  13.07   1106.75   14.3     129   130   I  131   -450.0  0.40   132  133  135    0   0
 132   2610.   900.   8364.  0.020  17.24    413.13    9.3     129   131   I  132      0.0  0.40   135  136  137  139   0
 133   1800.  1650.  12039.  0.020  25.00    -49.31    7.3     130   131   I  133      0.0  0.40   137    0    0    0   0
 134   2490.  2000.  32594.  0.017  19.07  -1156.07   16.3      14   130   I
 135   2580.  1350.   7149.  0.020  17.44    813.90    5.3     131   132   I
 136   2280.  2700.  11604.  0.020  19.74    -16.83    4.3      14   132   I
 137   2700.  1500.   6444.  0.022  16.67      0.01    4.3     132   133   I
 138   3750.  1800.  13160.  0.020  12.00   -796.85    7.3      79   132   I
 139   4140.  2250.  16508.  0.020  10.37    586.23    7.3      79    80   I


               **************   DIFFUSION CONSTANTS   **************

                    CHANNEL    CHANNEL           CONSTANT (C4)
               ---------------------------------------------------

                      1         139               25.00
```

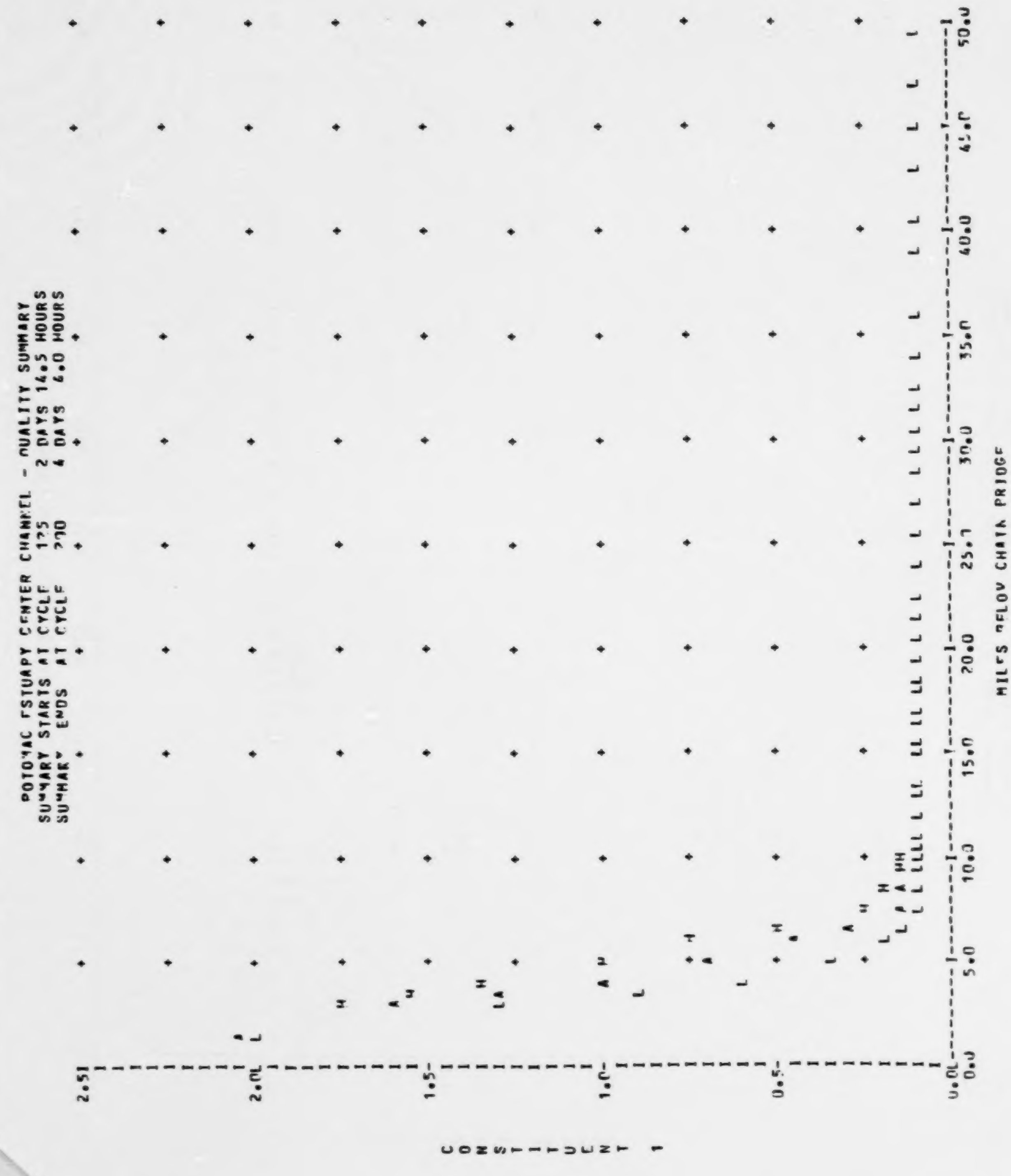
```
********************************    SUMMARY OF DISSOLVED OXYGEN (CONSTITUENT 6)  RATES     **********************************

                                    PHOTOSYNTHESIS      RESPIRATION     PHOTIC DEPTH     BENTHIC DEMAND
             FROM         TO            (PHOT)              (RES)          (DEPTH)           (BENT)
             JUNC        JUNC          (MG/HR/UG CHLORO)                   (FEET)
          -------------------------------------------------------------------------------------------

               0           0        0.0               0.0               0.0              0.0


*********************************    SUMMARY OF NUTRIENT UPTAKE AND REGENERATION RATES     **********************************

      FROM       TO     CONST 1 UPTAKE     CONST 3 UPTAKE     CONST 1 REGEN     CONST 3 REGEN     CONST 5 REGEN
      JUNC      JUNC       (AMUPP)            (PHUPP)            (REGENN)         (REGEPP)          (REBODD)
    -------------------------------------------------------------------------------------------------------------

        1       133          0.0               0.0               0.0               0.0               0.0


**************************************    SUMMARY OF CONSTITUENT DECAY RATES     **************************************

                           CONST 1        CONST 2        CONST 3 *       CONST 4        CONST 5        CONST 6
      FROM       TO      (DECAYK 1)     (DECAYK 2)     (DECAYK 3)     (DECAYK 4)     (DECAYK 5)     (DECAYK6)
      JUNC      JUNC     (PER DAY)      (PER DAY)      (PER DAY)      (PER DAY)      (PER DAY)      (PER DAY)
    -------------------------------------------------------------------------------------------------------------

        1       133         0.0            0.0            0.0


          ****************************    SUMMARY OF CONSTANT WASTEWATER  LOADS     ******************************

                              CONSTITUENT 1      CONSTITUENT 2      CONSTITUENT 3      CONSTITUENT 4      CONSTITUENT 5      CONSTITUENT 6
   JUNC.     TOTAL FLOW       CONC.    LOAD      CONC.    LOAD      CONC.    LOAD      CONC.    LOAD      CONC.    LOAD      CONC.    LOAD
               (CFS)        (MG/L) (LB/DAY)    (MG/L) (LB/DAY)    (MG/L) (LB/DAY)    (UG/L) (LB/DAY)    (MG/L) (LB/DAY)    (MG/L) (LB/DAY)
  -----------------------------------------------------------------------------------------------------------------------------------------

   131       -450.0          0.0        0.      1.0     2427.     0.0        0.
```

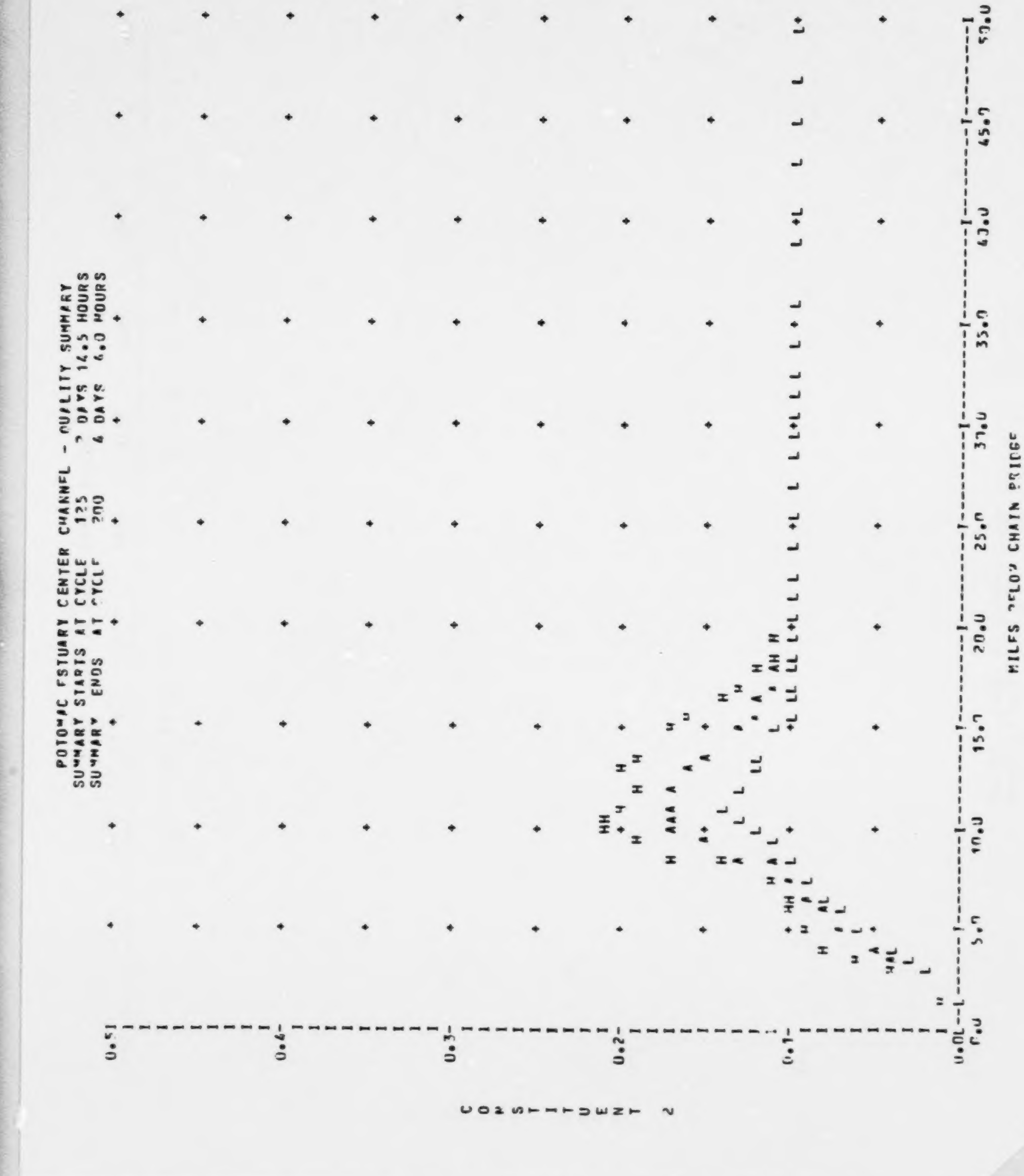
```
*****************************     SUMMARY OF VARIABLE WASTEWATER LOADS     *****************************

                INCREMENT              CONSTITUENT 1    CONSTITUENT 2    CONSTITUENT 3    CONSTITUENT 4    CONSTITUENT 5    CONSTITUENT6
JUNC.  DISCH.  NO.  LENGTH    FLOW    CONC.    LOAD    CONC.    LOAD    CONC.    LOAD    CONC.    LOAD    CONC.    LOAD    CONC.    LOAD
                   (CYCLES)  (CFS)   (MG/L) (LB/DAY)  (MG/L) (LB/DAY)  (MG/L) (LB/DAY)  (UG/L) (LB/DAY)  (MG/L) (LB/DAY)  (MG/L) (LB/DAY)
--------------------------------------------------------------------------------------------------------------------------------------------

131     1       1    125      0.0     0.0      0.     0.0      0.     0.0      0.
                2     25   -450.      0.0      0.     0.0      0.     2.0   4855.
                3    350      0.      0.0      0.     0.0      0.     0.0      0.



****************************     SUMMARY OF UPPER BOUNDARY CONDITIONS  (NODE 114)     ****************************

 INCREMENT               CONSTITUENT 1     CONSTITUENT 2     CONSTITUENT 3     CONSTITUENT 4     CONSTITUENT 5     CONSTITUENT 6
NO.  LENGTH     FLOW    CONC.    LOAD     CONC.    LOAD     CONC.    LOAD     CONC.    LOAD     CONC.    LOAD     CONC.    LOAD
   (CYCLES)    (CFS)   (MG/L)  (LB/DAY)  (MG/L)  (LB/DAY)  (MG/L)  (LB/DAY)  (UG/L)  (LB/DAY)  (MG/L)  (LB/DAY)  (MG/L)  (LB/DAY)
------------------------------------------------------------------------------------------------------------------------------------

 1     500    -1500.    2.00    16132.    0.0        0.    0.0        0.



*********************************     SUMMARY OF INITIAL CONCENTRATIONS     *********************************

                 FROM     TO     CONST 1    CONST 2    CONST 3    CONST 4    CONST 5    CONST 6
                 JUNC    JUNC    (MG/L)     (MG/L)     (MG/L)     (UG/L)     (MG/L)     (MG/L)
          ------------------------------------------------------------------------------------

                  1      133      0.10       0.10       0.10
```

```
*********************************   TIDAL CYCLE VARIATION OF SEAWARD BOUNDARY CONDITIONS   *****************************

                                                  SPECIFIED CONCENTRATIONS AT JUNCTION 1

     INTERVAL      CONSTITUENT 1      CONSTITUENT 2      CONSTITUENT 3      CONSTITUENT 4      CONSTITUENT 5      CONSTITUENT 6
                      (MG/L)             (MG/L)             (MG/L)             (UG/L)             (MG/L)             (MG/L)
-------------------------------------------------------------------------------------------------------------------------------

         1             0.0                0.0                0.0
         2             0.0                0.0                0.0
         3             0.0                0.0                0.0
         4             0.0                0.0                0.0
         5             0.0                0.0                0.0
         6             0.0                0.0                0.0
         7             0.0                0.0                0.0
         8             0.0                0.0                0.0
         9             0.0                0.0                0.0
        10             0.0                0.0                0.0
        11             0.0                0.0                0.0
        12             0.0                0.0                0.0
        13             0.0                0.0                0.0
        14             0.0                0.0                0.0
        15             0.0                0.0                0.0
        16             0.0                0.0                0.0
        17             0.0                0.0                0.0
        18             0.0                0.0                0.0
        19             0.0                0.0                0.0
        20             0.0                0.0                0.0
        21             0.0                0.0                0.0
        22             0.0                0.0                0.0
        23             0.0                0.0                0.0
        24             0.0                0.0                0.0
        25             0.0                0.0                0.0
     ***********************************************      WATER QUALITY SUMMARY      ***********************************************
       STARTS AT CYCLE  125 (  2 DAYS 14.5 HOURS)                                  ENDS AT CYCLE  200 (  4 DAYS   4.0 HOURS)

JUNC.   CONSTITUENT 1        CONSTITUENT 2        CONSTITUENT 3        CONSTITUENT 4        CONSTITUENT 5        CONSTITUENT 6
       MIN   MAX   AVG      MIN   MAX   AVG      MIN   MAX   AVG      MIN   MAX   AVG      MIN   MAX   AVG      MIN   MAX   AVG
----------------------------------------------------------------------------------------------------------------------------------

  1    0.0   0.0   0.0      0.0   0.0   0.0      0.0   0.0   0.0
  2    1.98  2.04  2.03     0.0   0.01  0.00     0.0   0.01  0.00
  3    1.32  1.77  1.60     0.02  0.04  0.02     0.02  0.04  0.02
  4    0.92  1.57  1.31     0.03  0.06  0.04     0.03  0.04  0.04
  5    0.59  1.35  1.02     0.04  0.08  0.05     0.04  0.08  0.05
  6    0.33  1.01  0.69     0.06  0.09  0.07     0.06  0.09  0.07
  7    0.19  0.74  0.45     0.07  0.10  0.08     0.07  0.10  0.08
  8    0.13  0.51  0.28     0.08  0.10  0.09     0.08  0.10  0.09
  9    0.10  0.24  0.16     0.09  0.11  0.10     0.09  0.10  0.10
 10    0.10  0.21  0.13     0.10  0.14  0.11     0.09  0.11  0.10
 11    0.09  0.19  0.12     0.10  0.17  0.13     0.09  0.14  0.11
 12    0.09  0.15  0.11     0.11  0.19  0.15     0.09  0.14  0.11
 13    0.09  0.13  0.10     0.12  0.21  0.17     0.09  0.17  0.12
 14    0.09  0.11  0.09     0.14  0.23  0.17     0.09  0.15  0.12
 15    0.09  0.10  0.09     0.13  0.19  0.17     0.10  0.14  0.11
 16    0.09  0.10  0.09     0.12  0.20  0.16     0.09  0.14  0.11
 17    0.09  0.10  0.09     0.12  0.19  0.15     0.09  0.12  0.10
 18    0.09  0.10  0.10     0.11  0.17  0.13     0.10  0.11  0.10
 19    0.09  0.10  0.10     0.10  0.16  0.12     0.10  0.11  0.10
 20    0.10  0.10  0.10     0.10  0.14  0.12     0.10  0.10  0.10
 21    0.10  0.10  0.10     0.10  0.13  0.11     0.10  0.10  0.10
 22    0.10  0.10  0.10     0.10  0.12  0.11     0.10  0.10  0.10
 23    0.10  0.10  0.10     0.10  0.11  0.10     0.10  0.10  0.10
 24    0.10  0.10  0.10     0.10  0.11  0.10     0.10  0.10  0.10
 25    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 26    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 27    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 28    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 29    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 30    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 31    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 32    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 33    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 34    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 35    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 36    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 37    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 38    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 39    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 40    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 41    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 42    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 43    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 44    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 45    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
 46    0.10  0.10  0.10     0.10  0.10  0.10     0.10  0.10  0.10
```

49	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
50	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
51	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
52	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
54	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
55	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
56	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
57	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
58	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
59	0.09	0.10	0.10	0.09	0.10	0.10	0.09	0.10	0.10
60	0.09	0.10	0.09	0.09	0.10	0.09	0.09	0.10	0.09
61	0.07	0.09	0.09	0.07	0.09	0.09	0.07	0.09	0.09
62	0.06	0.09	0.07	0.06	0.09	0.07	0.06	0.09	0.07
63	0.04	0.08	0.06	0.04	0.08	0.06	0.04	0.08	0.06
64	0.03	0.06	0.04	0.03	0.06	0.04	0.03	0.06	0.04
65	0.01	0.03	0.01	0.01	0.03	0.01	0.01	0.03	0.01
66	0.10	0.19	0.13	0.10	0.10	0.10	0.10	0.10	0.10
67	0.10	0.15	0.12	0.10	0.10	0.10	0.10	0.10	0.10
68	0.10	0.13	0.11	0.10	0.10	0.10	0.10	0.10	0.10
69	0.10	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10
70	0.10	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10
71	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
72	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
73	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
74	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
75	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
76	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
77	0.09	0.10	0.10	0.09	0.10	0.10	0.09	0.10	0.10
78	0.10	0.10	0.10	0.11	0.12	0.12	0.10	0.10	0.10
79	0.08	0.09	0.09	0.18	0.24	0.22	0.09	0.18	0.13
80	0.09	0.09	0.09	0.15	0.22	0.19	0.09	0.14	0.12
81	0.09	0.10	0.10	0.12	0.16	0.14	0.09	0.11	0.10
82	0.10	0.10	0.10	0.11	0.12	0.11	0.10	0.10	0.10
83	0.10	0.10	0.10	0.10	0.11	0.10	0.10	0.10	0.10
84	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
85	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
86	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
87	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
88	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
89	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
90	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
91	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
92	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
93	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
94	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
95	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
96	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
97	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
98	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
99	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
100	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
101	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
102	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
103	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
104	0.09	0.10	0.09	0.09	0.10	0.09	0.09	0.10	0.09
105	0.09	0.10	0.09	0.09	0.10	0.09	0.09	0.10	0.09
106	0.07	0.09	0.08	0.07	0.09	0.08	0.07	0.09	0.08
107	0.06	0.08	0.07	0.06	0.08	0.07	0.06	0.08	0.07

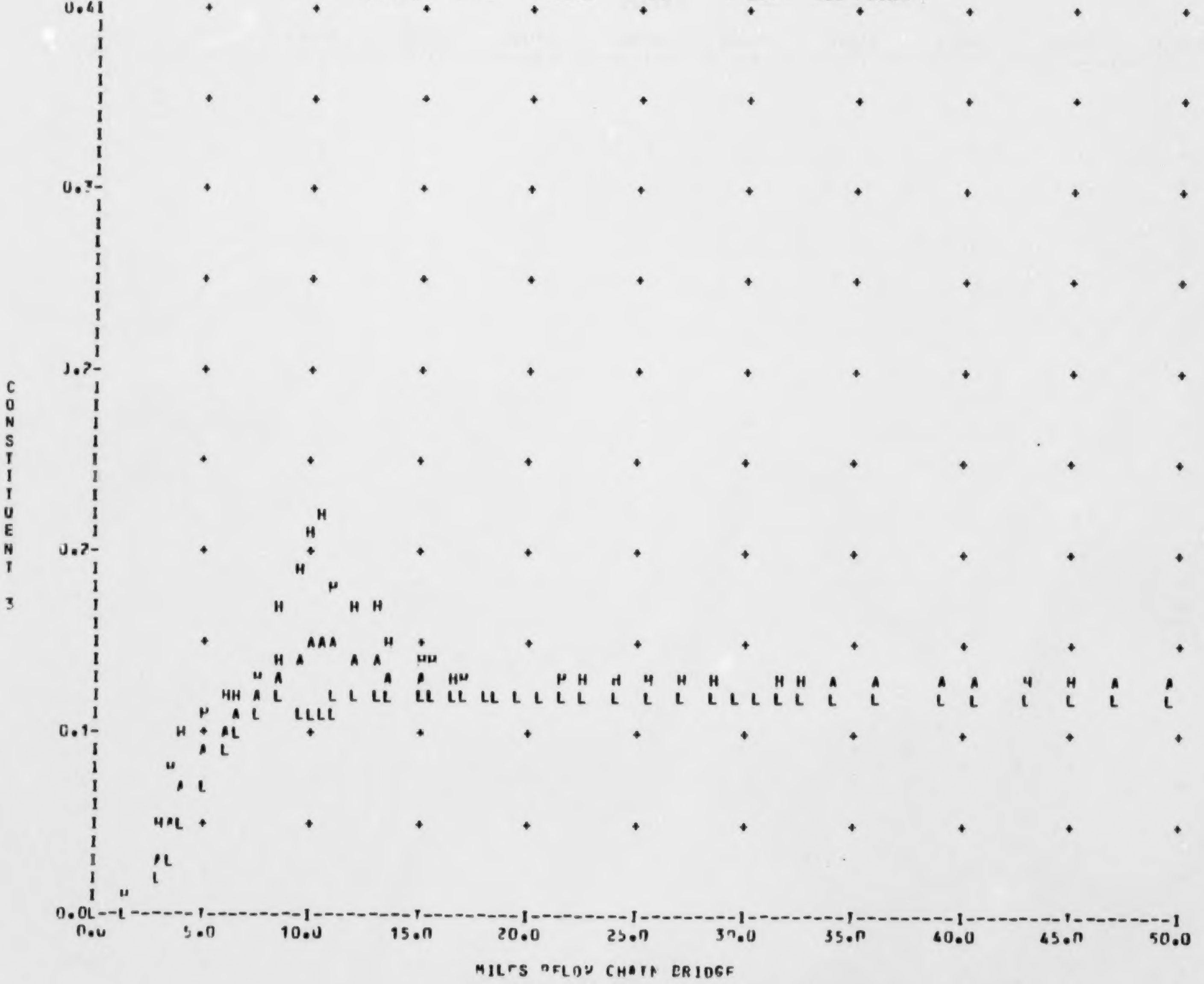
```
110   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
111   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
112   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
113   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
114   1.99  2.01  2.00    0.0   0.0   0.0     0.0   0.0   0.0
115   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
116   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
117   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
118   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
119   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
120   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
121   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
122   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
123   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
124   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
125   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
126   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
127   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
128   0.10  0.10  0.10    0.10  0.10  0.10    0.10  0.10  0.10
129   0.09  0.12  0.10    0.13  0.21  0.17    0.09  0.13  0.12
130   0.09  0.11  0.09    0.14  0.20  0.17    0.09  0.14  0.12
131   0.07  0.08  0.08    0.27  0.40  0.31    0.08  0.50  0.21
132   0.06  0.09  0.03    0.20  0.27  0.24    0.08  0.24  0.15
133   0.09  0.09  0.09    0.15  0.20  0.17    0.08  0.12  0.10

                NUMBER OF QUALITY CYCLES =   500
                HYDRAULIC TAPE LAST READ AT CYCLE  1500
```

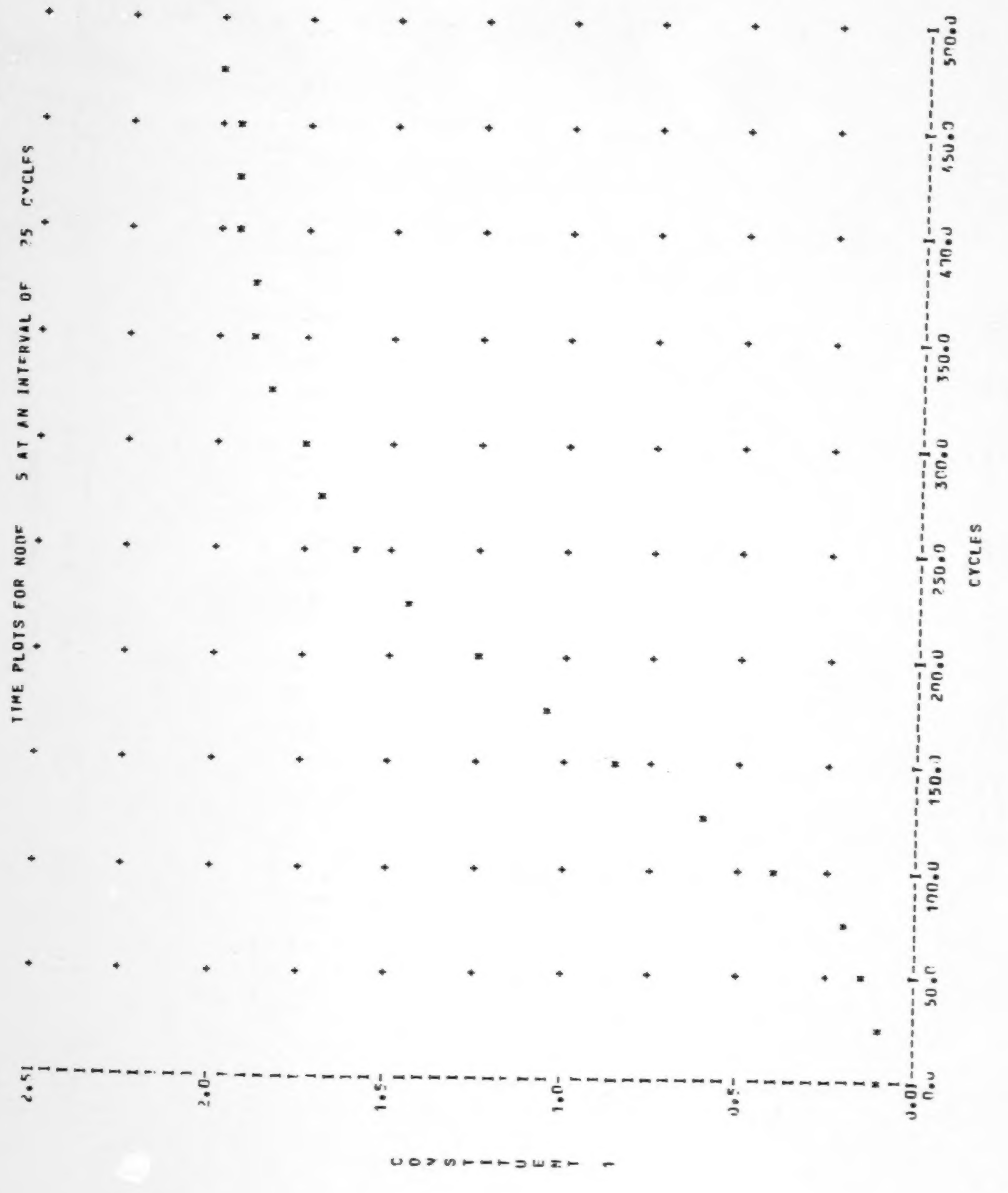

POTOMAC ESTUARY CENTER CHANNEL - QUALITY SUMMARY
SUMMARY STARTS AT CYCLE 175 2 DAYS 14.5 HOURS
SUMMARY ENDS AT CYCLE 290 4 DAYS 4.0 HOURS
CONSTITUENT 1
2.51
2.0
1.5
1.0
0.5
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
MILES BELOW CHAIN BRIDGE
H
A
L

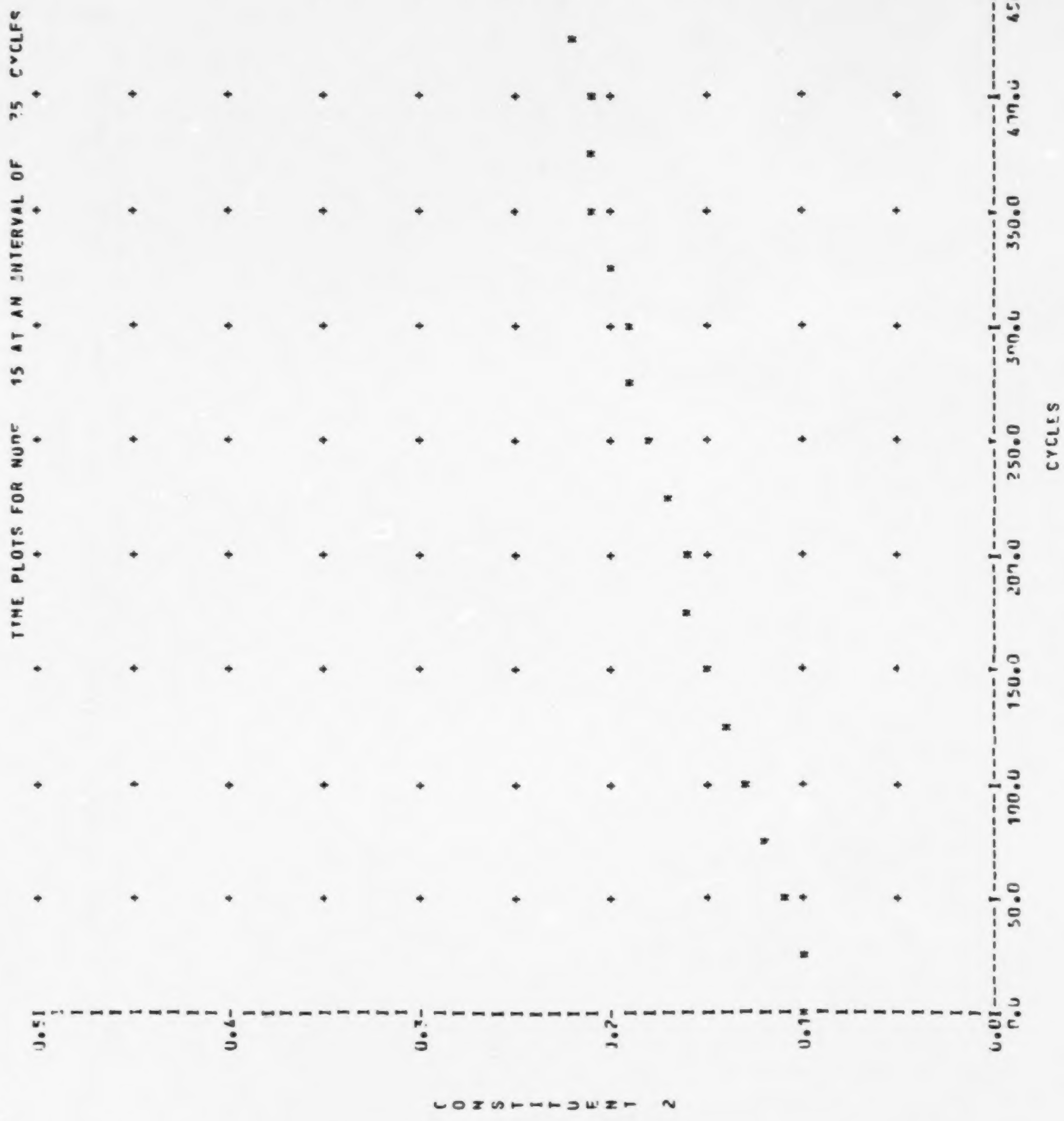


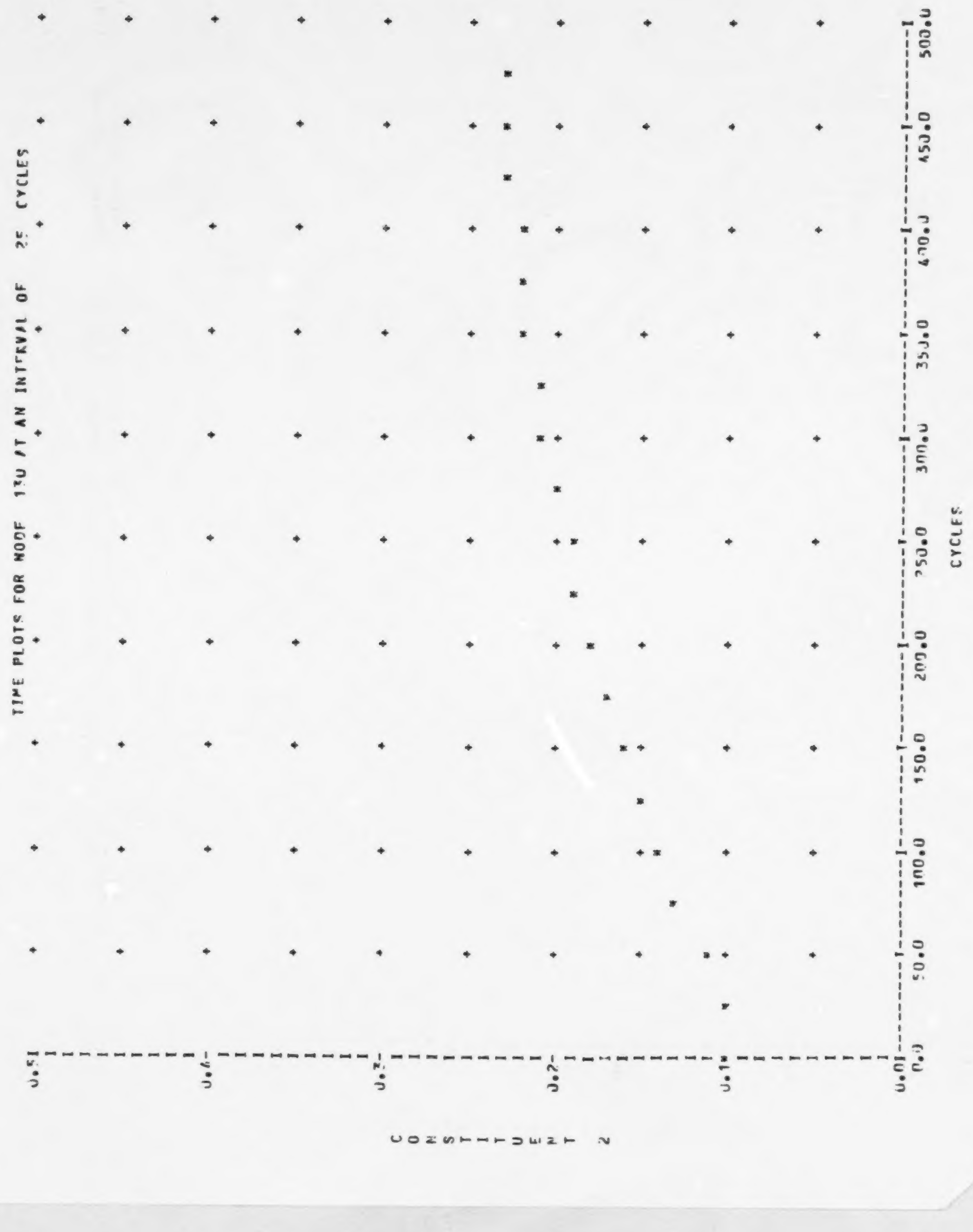
POTOMAC ESTUARY CENTER CHANNEL - QUALITY SUMMARY
SUMMARY STARTS AT CYCLE 125 2 DAYS 14.5 HOURS
SUMMARY ENDS AT CYCLE 200 4 DAYS 6.0 HOURS

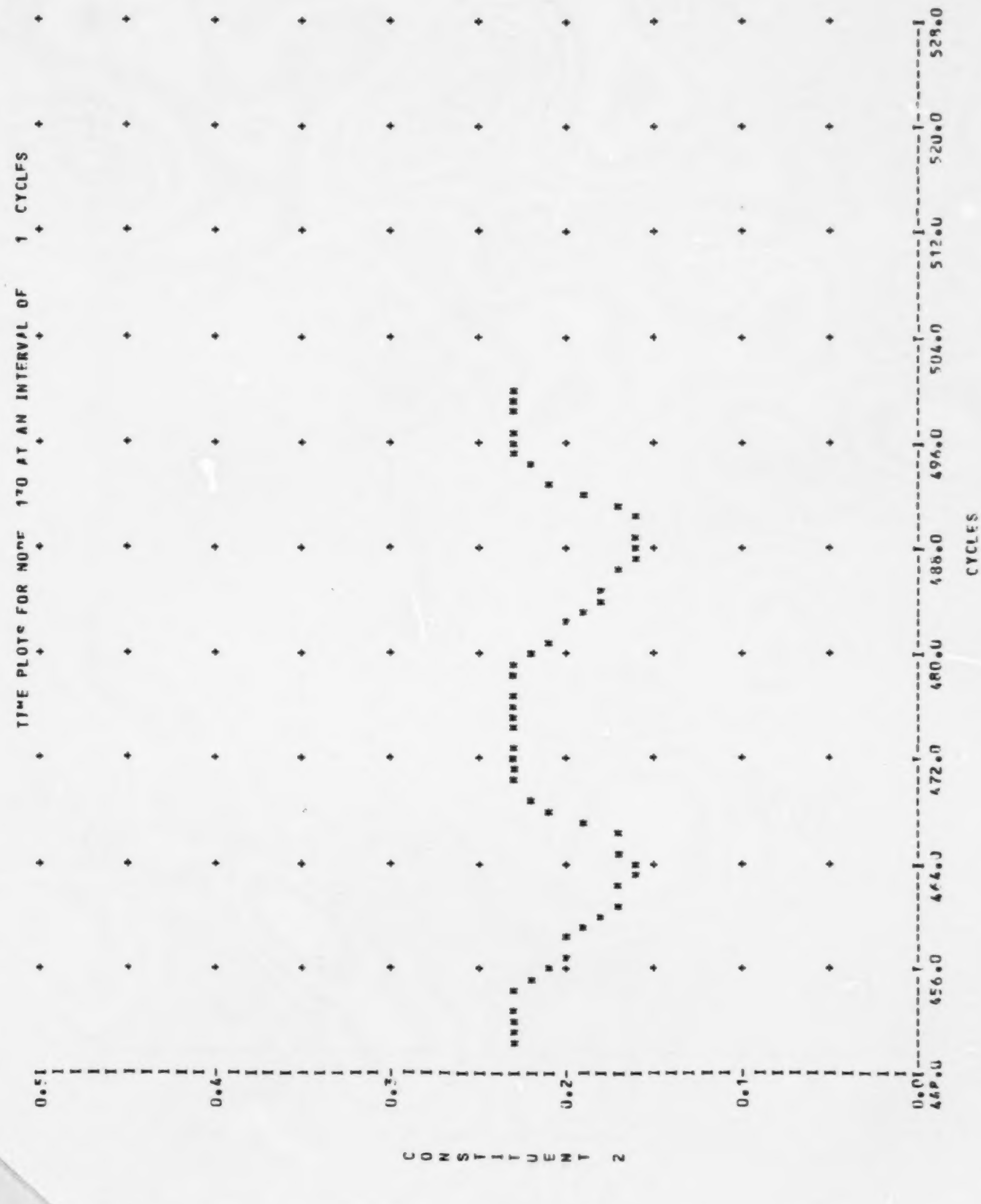
POTOMAC ESTUARY CENTER CHANNEL - QUALITY SUMMARY
SUMMARY STARTS AT CYCLE 125 2 DAYS 14.5 HOURS
SUMMARY ENDS AT CYCLE 200 4 DAYS 4.0 HOURS



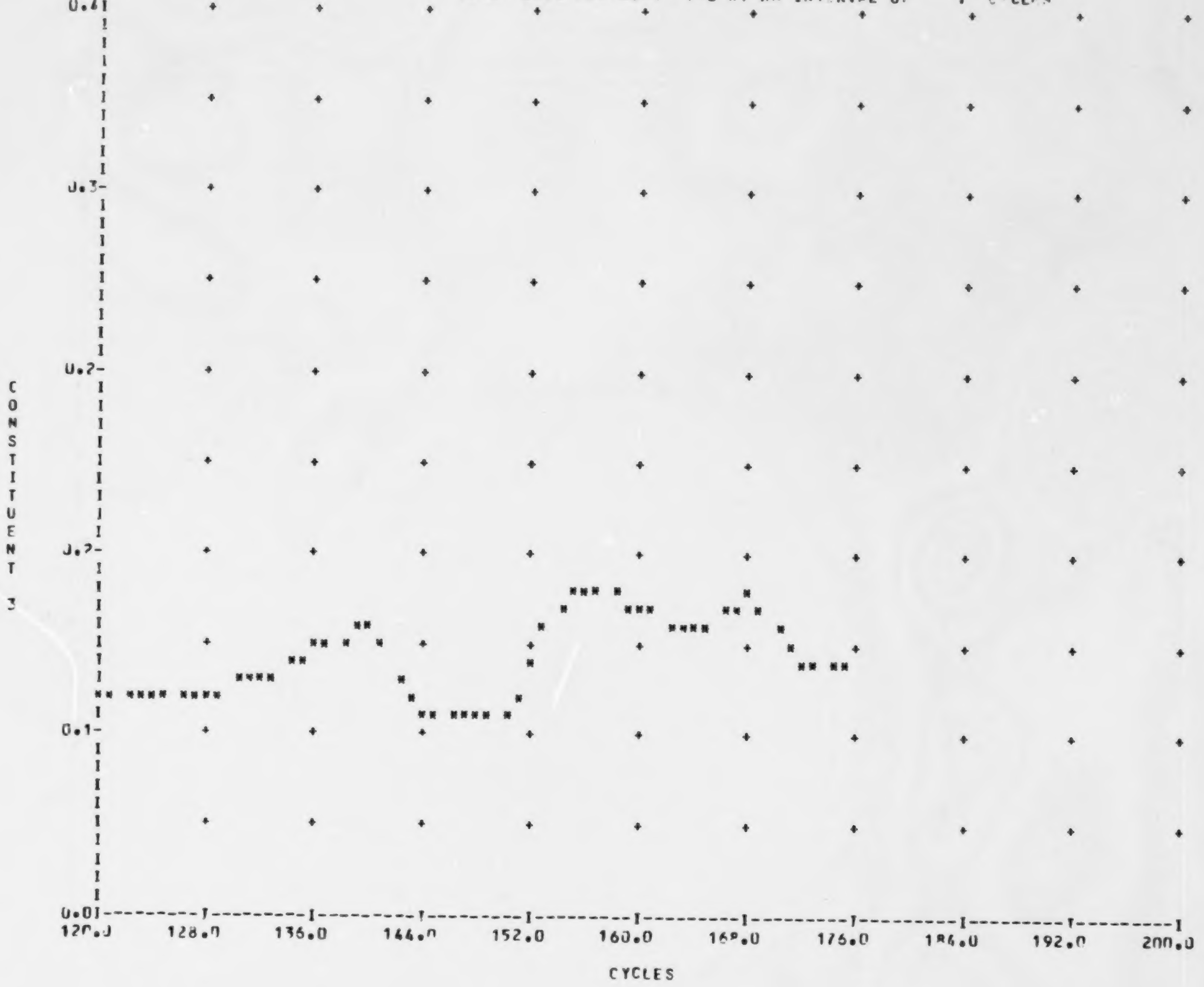

TIME PLOTS FOR NODE 5 AT AN INTERVAL OF 25 CYCLES
CONSTITUENT 1
2.5
2.0
1.5
1.0
0.5
0.0
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
500.0
CYCLES


TIME PLOTS FOR NODE 15 AT AN INTERVAL OF 25 CYCLES
CONSTITUENT 2
CYCLES
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
500.0
0.00
0.1
0.2
0.3
0.4
0.5


TIME PLOTS FOR NODE 150 AT AN INTERVAL OF 25 CYCLES
CONSTITUENT 2
0.0
0.1
0.2
0.3
0.4
0.5
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
500.0
CYCLES


TIME PLOTS FOR NODE 170 AT AN INTERVAL OF 1 CYCLES
0.5
0.4
0.3
0.2
0.1
0.0
CONSTITUENT 2
448.0
456.0
464.0
472.0
480.0
488.0
496.0
504.0
512.0
520.0
528.0
CYCLES

TIME PLOTS FOR NODE 130 AT AN INTERVAL OF 1 CYCLES



4.4.2 2 LINKED CONSTITUENTS

-- data deck listing --

```
DYNQUAL - SAMPLE RUN 2  -  THIS RUN SIMULATES THE NITRIFICATION PROCESS
                           IN THE POTOMAC ESTUARY
  133  139 1500 2000   20
INDEPENDENT CONTROL DATA - RUN 2
 1500  500  999  999   25
    2    0    1    5
        30.       6.00
TABULAR OUTPUT CONTROL - RUN 2
    0
    0
    3
  100    0    1
  300    1    1
  400    2    1
PLOTTING OUTPUT CONTROL  - RUN 2
    0    3    2
    5    1
  209
    1    1
   .5   0.  2.5   0.
QUALITY COEFFICIENTS - RUN 2
         0.        1.         1.         1.
         0.      1.198      100.  NH3
         0.      1.00       100. NO2+NO3
DIFFUSION CONSTANTS - RUN 2
    2
         1         65        25.
        66        133        10.
UPTAKE / REGENERATION RATES - RUN 2
    1
         1        133         0.         0.         0.         0.         0.
DECAY RATES - RUN 2
    7
         1          1        .03        0.0
         2         20        .07        0.0
        21        113        .03        0.0
       114        114        .07        0.0
       115        128        .03        0.0
       129        130        .07        0.0
       131        133        .03        0.0
WASTEWATER INPUTS - RUN 2
    1    0    0
CONSTANT INPUTS
       131      -450.         4.         .5
UPPER BOUNDARY CONDITIONS - RUN 2
    1
       500     -1500.        .2         .2
INITIAL CONDITIONS - RUN 2
         1         10        .1         .1
        11         20        1.         1.
        21        128        .1         .1
       129        133        1.         1.
SEAWARD BOUNDARY CONDITIONS - RUN 2
    1    1
   .1
   .1
OBSERVED DATA SET # 1
 .06 .07 .05  .4  .3  .2                                                 5.
  .2 .17 .14 1.4 1.3  1.                                                15.
 .07 .05 .02  .5  .3  .1                                                25.
 .06 .04 .03 .35 .25  .1                                                35.
 .04 .03 .02 .35 .25  .1                                                45.
```

-- *output listing* --

```
POTOMAC ESTUARY HYDRAULICS  -  133 JUNCTION NETWORK                                              ENVIRONMENTAL PROTECTION AGENCY
FLOW = 1500 CFS AT CHAIN BRIDGE, 450 CFS AT BLUE PLAINS, 0 AT OTHER STP'S                             DYNAMIC ESTUARY MODEL
DYNQUAL - SAMPLE RUN 2  -  THIS RUN SIMULATES THE NITRIFICATION PROCESS
                           IN THE POTOMAC ESTUARY

 ************************   HYDRAULIC CONTROL DATA   ************************

 FIRST CYCLE ON     LAST CYCLE  ON    BEGIN READING TAPE     HYDRAULIC
 HYDRAULIC TAPE     HYDRAULIC TAPE         AT CYCLE        TIME STEP (SEC.)
    (NSTART)           (NSTOP)            (HYDCYC)             (DELT)

      1500               2000               1500                90.00

 ********************************************   QUALITY CONTROL DATA   ********************************************

          NUMBER OF           NUTRIENT LIMITATION        D.O. SUMMARY        QUALITY          QUALITY STEPS
        QUALITY CYCLES      SUMMARY BEGINS AT CYCLE     BEGINS AT CYCLE   TIME STEP (HRS)    PER TIDAL PERIOD
           (NQCYC)                 (NUTCYC)                (NDOCYC)          (DELTQ1)            (NSPEC)

             500                     999                     999               0.50                 25

  NUMBER OF                      STARTING TIME    TIME OF    TIME OF    D.O. SATURATION
 CONSTITUENTS    TEMPERATURE     FOR THIS RUN     SUNRISE    SUNSET      AT 30.00  C
   (NUMCON)         (TEMP)          (STIME)       (TSRISE)   (TSSET)        (CSAT)

      2              30.00            6.00          0.0        0.0           0.0


 CONSTITUENT    CONSTITUENT     BACKGROUND         TEMPERATURE
   NUMBER          NAME        CONCENTRATION    CORRECTION FACTOR
                  (CNAME)         (BACKC)            (THETA)

      1            NH3              0.0               1.183
      2          NO2+NO3            0.0               1.000

                                                                         PERCENT OF DECAYED ALGAE
 CHLOROPHYLL/NITROGEN    CHLOROPHYLL/PHOSPHOROUS    CHLOROPHYLL/CARBON    WHICH IS BIO-DEGRADABLE
      (CHLNIT)                  (CHLPHO)                 (CHLCAR)                  (PERCD)

        1.00                      1.00                     1.00                      0.0

 ONLY NITROGEN UPTAKE BY ALGAE IS CONSIDERED  (KREAC = 1)
 CONSTITUENT CONCENTRATIONS IN ADVECTED WATER ARE COMPUTED USING THE 2-WAY PROPORTIONAL METHOD (MIX=5)
```

```
***************************************************   SUMMARY OF HYDRAULIC INPUTS   ***************************************************

           CROSS-SECTIONAL AREA AND HYDRAULIC RADIUS OF CHANNELS AND JUNCTION HEADS ARE AT MEAN TIDE

*******************************  CHANNEL DATA  ***********************************     ***************  JUNCTION DATA  **************
CHAN  LENGTH  WIDTH   CS-AREA  MANNING  DIFF   NET FLOW   HYD. RAD.  JUNC. AT ENDS  |  JUNC  INFLOW  HEAD    CHANNELS INTO JUNCTION
----------------------------------------------------------------------------------|------------------------------------------------
  1    7814.    224.     3783.  0.020    5.76  -1499.97     16.9        2    114    |    1     0.0   0.33    65    0    0    0    0
  2    7676.    800.    24853.  0.020    6.36   1499.98     31.1        2      3    |    2     0.0   0.40     1    2    0    0    0
  3    2551.    955.    32431.  0.020   15.79   1499.99     34.0        3      4    |    3     0.0   0.40     2    3    0    0    0
  4    4065.   1183.    22681.  0.020   11.07   1500.01     19.2        4      5    |    4     0.0   0.40     3    4    0    0    0
  5    3749.   1521.    23982.  0.020   12.09   1500.02     15.8        5      6    |    5     0.0   0.40     4    5    0    0    0
  6    5597.   1545.    23115.  0.020    9.04   1499.91     11.9        6      7    |    6     0.0   0.40     5    6    0    0    0
  7    3510.   2359.    22518.  0.020   12.53   1499.87      9.6        7      8    |    7     0.0   0.40     6    7    0    0    0
  8    5438.   2912.    25663.  0.020    9.27   1499.83      8.9        8      9    |    8     0.0   0.40     7    8    0    0    0
  9    4065.   2920.    31228.  0.020   11.07   1519.87     10.7        9     10    |    9     0.0   0.40     8    9   65    0    0
 10    1690.   2953.    38725.  0.017   26.63   1519.89     13.1       10     11    |   10     0.0   0.40     9   10    0    0    0
 11    3696.   3258.    39852.  0.017   12.19   1519.86     12.2       11     12    |   11     0.0   0.40    10   11    0    0    0
 12    3010.   3503.    38684.  0.017   14.95   1519.92     11.0       12     13    |   12     0.0   0.40    11   12   77    0    0
 13    2370.   2675.    36055.  0.017   19.82   1519.87     14.6       13    129    |   13     0.0   0.40    12   13    0    0    0
 14    3690.   2100.    30055.  0.017   12.29   1172.86     14.3       14     15    |   14     0.0   0.40    14  134  135    0    0
 15    4150.   2340.    26529.  0.017   10.77   1383.42     11.3       15     16    |   15     0.0   0.40    14   15   78    0    0
 16    3655.   7738.    45378.  0.017   11.67   1969.85     13.1       16     17    |   16     0.0   0.40    15   16   79   80    0
 17    6177.   4671.    53702.  0.017    7.29   1969.84     11.5       17     18    |   17     0.0   0.40    16   17    0    0    0
 18    2640.   5506.    53294.  0.017   17.05   1969.83      9.7       18     19    |   18     0.0   0.40    17   18    0    0    0
 19    5366.   4117.    57024.  0.017    8.35   1969.79     13.9       19     20    |   19     0.0   0.40    18   19   81    0    0
 20    3274.   3337.    56147.  0.017   13.74   1969.76     16.6       20     21    |   20     0.0   0.40    19   20    0    0    0
 21    5269.   3052.    56163.  0.017    8.57   1969.73     18.4       21     22    |   21     0.0   0.40    20   21    0    0    0
 22    3609.   3319.    72579.  0.017   14.94   1969.72     21.9       22     23    |   22     0.0   0.40    21   22    0    0    0
 23    5227.   4221.    75968.  0.017    8.61   1969.59     18.0       23     24    |   23     0.0   0.40    22   23   82    0    0
 24    5069.   5967.    74674.  0.017    8.63   1969.51     12.5       24     25    |   24     0.0   0.40    23   24    0    0    0
 25    5016.   5355.    73751.  0.017    8.97   1969.40     13.8       25     26    |   25     0.0   0.40    24   25    0    0    0
 26    4605.   4388.    68192.  0.017    9.37   1969.33     15.5       26     27    |   26     0.0   0.40    25   26    0    0    0
 27    8765.   5469.    81964.  0.017    5.13   1969.14     15.0       27     28    |   27     0.0   0.40    26   27   83    0    0
 28    9061.   6604.    94185.  0.017    4.96   1967.33     14.3       28     29    |   28     0.0   0.40    27   28   84    0    0
 29    6706.   4223.   105827.  0.017    6.71   1966.81     17.0       29     30    |   29     0.0   0.40    28   29    0    0    0
 30    8342.   7308.   110934.  0.017    5.39   1966.23     15.2       30     31    |   30     0.0   0.40    29   30    0    0    0
 31    5597.   8633.   117920.  0.017    8.04   1965.73     13.3       31     32    |   31     0.0   0.40    30   31    0    0    0
 32    5650.   7562.   127836.  0.017    7.96   1965.26     16.9       32     33    |   32     0.0   0.39    31   32    0    0    0
 33    4065.   7908.   127938.  0.017   11.07   1965.07     16.2       33     34    |   33     0.0   0.39    32   33    0    0    0
 34    6706.  10273.   132188.  0.017    6.71   2278.61     12.9       34     35    |   34     0.0   0.39    33   34   85    0    0
 35    8026.  13474.   162228.  0.014    5.61   1725.22     12.0       35     36    |   35     0.0   0.39    34   35   86    0    0
 36   10507.  10224.   193741.  0.014    4.29   1960.65     18.0       36     37    |   36     0.0   0.39    35   36   89   90  130
 37   13464.   7824.   171952.  0.014    3.36   1959.69     22.0       37     38    |   37     0.0   0.39    36   37   91    0    0
 38    9715.   8934.   176359.  0.014    4.63   1959.33     19.7       38     39    |   38     0.0   0.39    37   38   92    0    0
 39   12146.  12130.   202136.  0.014    3.71   1958.33     16.7       39     40    |   39     0.0   0.38    38   39    0    0    0
 40   10576.  16807.   230127.  0.014    4.14   1956.80     13.7       40     41    |   40     0.0   0.38    39   40    0    0    0
 41   11244.  14701.   232151.  0.014    4.00   1954.86     13.9       41     42    |   41     0.0   0.38    40   41    0    0    0
 42   12460.  14315.   217678.  0.014    3.61   1953.03     15.2       42     43    |   42     0.0   0.38    41   42   93    0    0
 43   12830.  13802.   219580.  0.014    3.51   1951.75     15.9       43     44    |   43     0.0   0.37    42   43   94    0    0
 44   10624.  11116.   197979.  0.014    4.14   1949.82     17.8       44     45    |   44     0.0   0.37    43   44    0    0    0
 45   17529.   8074.   186689.  0.014    2.57   1949.09     20.9       45     46    |   45     0.0   0.37    44   45    0    0    0
 46   10560.  10617.   195254.  0.014    4.26   1947.52     18.5       46     47    |   46     0.0   0.36    45   46    0    0    0
 47   142[illegible].  127[illegible].   [illegible]523.  0.014    7.1[illegible]   1945.[illegible]     15.6       47     48    |   47     0.1   0.36    46   47   95    0    0
 50    9620.  13325.  251552.  0.014   4.58   1943.40   24.4     50   51  |  50    0.0  0.34   49   50    0    0   0
 51    6441.  17716.  347154.  0.014   6.99   1943.13   19.6     51   52  |  51    0.0  0.34   50   51    0    0   0
 52   10560.  25490.  659412.  0.014   4.26   1942.93   18.0     52   53  |  52    0.0  0.34   51   52   97    0   0
 53    9451.  21717.  602421.  0.014   4.76   1942.44   18.5     53   54  |  53    0.0  0.34   52   53    0    0   0
 54    6611.  24187.  634251.  0.014   6.61   1941.48   18.0     54   55  |  54    0.0  0.34   53   54    0    0   0
 55   10665.  30413.  556047.  0.014   4.22   1942.11   18.3     55   56  |  55    0.0  0.34   54   55   98    0   0
 56   10137.  31129.  625565.  0.014   4.44   1942.17   20.1     56   57  |  56    0.0  0.34   55   56    0    0   0
 57    8712.  33034.  658347.  0.014   5.17   1940.47   19.9     57   58  |  57    0.0  0.34   56   57   99    0   0
 58   12302.  27015.  568689.  0.014   3.66   1940.15   21.0     58   59  |  58    0.0  0.34   57   58    0    0   0
 59   10612.  25560.  524251.  0.014   6.24   1940.20   20.6     59   60  |  59    0.0  0.34   58   59    0    0   0
 60   11615.  29075.  574128.  0.014   3.07   1939.67   19.7     60   61  |  60    0.0  0.33   59   60  101  103   0
 61    6705.  28258.  602987.  0.014   6.71   1939.23   21.3     61   62  |  61    0.0  0.33   60   61  102    0   0
 62    8712.  27676.  606665.  0.014   5.17   1939.51   21.9     62   63  |  62    0.0  0.33   61   62    0    0   0
 63    8655.  25729.  625313.  0.014   5.20   1939.42   24.3     63   64  |  63    0.0  0.33   62   63  104    0   0
 64    8659.  24386.  690297.  0.014   5.20   1939.30   27.9     64   65  |  64    0.0  0.33   63   64    0    0   0
 65   16104.  22510.  733238.  0.014   2.79  -1939.18   32.6      1   65  |  65    0.0  0.33   64   65    0    0   0
 66    2600.   3200.   61256.  0.024   6.92    -19.91   19.1      9   66  |  66    0.0  0.40   66   67  110    0   0
 67    2640.   1500.   31398.  0.024   6.82    -20.04   20.9     66   67  |  67    0.0  0.40   67   68    0    0   0
 68    2380.   1250.   27185.  0.024   7.56    -20.04   21.7     67   68  |  68    0.0  0.40   68   69    0    0   0
 69    2510.   1250.   27182.  0.024   7.17    -20.03   21.7     68   69  |  69    0.0  0.40   69   70    0    0   0
 70    2640.   1150.   24786.  0.024   6.82    -20.03   21.6     69   70  |  70    0.0  0.40   70   71    0    0   0
 71    7035.    750.   14488.  0.024   5.53    -20.02   19.3     70   71  |  71    0.0  0.40   71   72    0    0   0
 72    3430.    750.    8618.  0.024   5.25    -20.02   11.5     71   72  |  72    0.0  0.40   72   73    0    0   0
 73    3300.    750.    8681.  0.024   5.45    -20.01   11.6     72   73  |  73    0.0  0.40   73   74  113    0   0
 74    3035.    550.    3149.  0.026   5.93    -19.69    5.7     73   74  |  74    0.0  0.40   74   75    0    0   0
 75    3430.    400.    4805.  0.026   5.25    -19.69   12.0     74   75  |  75    0.0  0.40   75   76    0    0   0
 76    3565.    350.    2670.  0.026   5.05    -19.69    8.2     75   76  |  76    0.0  0.40   76  105  115    0   0
 77    4030.   1311.   16144.  0.022   3.73      0.01   12.3     12   78  |  77    0.0  0.40  105  106    0    0   0
 78    2100.   4500.   19473.  0.020   8.57   -210.55    4.3     15   79  |  78    0.0  0.40   77    0    0    0   0
 79    3450.   4200.   30863.  0.020   5.22   -586.20    7.3     16   80  |  79    0.0  0.40   78  138  139    0   0
 80    3405.   6231.   21119.  0.022   5.29      0.03    3.4     16   81  |  80    0.0  0.40   79  139    0    0   0
 81    5150.   2922.   12456.  0.022   3.27      0.04    4.3     19   82  |  81    0.0  0.40   80    0    0    0   0
 82    3700.   3412.   13886.  0.022   4.86      0.12    4.1     23   83  |  82    0.0  0.40   81    0    0    0   0
 83    4320.   4140.   12598.  0.022   4.17      0.08    3.0     27   84  |  83    0.0  0.40   82  116    0    0   0
 84   10530.   4216.   24678.  0.022   1.71      0.56    4.0     28   85  |  84    0.0  0.40   83    0    0    0   0
 85    6250.   8000.   40765.  0.022   2.89   -314.21    5.1     34   86  |  85    0.0  0.40   84  120    0    0   0
 86   10000.   7250.   59191.  0.022   1.80    552.80    8.2     35   87  |  86    0.0  0.39   85   87   68    0   0
 87    7350.   9930.   72642.  0.022   2.45   -315.33    7.3     86   87  |  87    0.0  0.39   86   87  129    0   0
 88   12855.   5401.   25708.  0.022   1.40      0.54    4.8     66   88  |  88    0.0  0.39   88    0    0    0   0
 89    8190.   2347.    6229.  0.022   2.20      0.15    2.7     36   89  |  89    0.0  0.39   89    0    0    0   0
 90   16200.   4601.   39860.  0.022   1.11      0.57    8.7     36   90  |  90    0.0  0.39   90    0    0    0   0
 91    6450.   3531.    9184.  0.022   2.79      0.17    2.6     37   91  |  91    0.0  0.39   91    0    0    0   0
 92   12180.   2408.    8465.  0.022   1.48      0.24    3.5     38   92  |  92    0.0  0.38   92    0    0    0   0
 93   26700.   3786.   17163.  0.022   0.67      0.93    4.5     42   93  |  93    0.0  0.37   93    0    0    0   0
 94   22410.   3435.   12156.  0.022   0.80      0.65    3.5     43   94  |  94    0.0  0.37   94    0    0    0   0
 95   27610.   5027.   17999.  0.022   0.73      0.88    3.6     47   95  |  95    0.0  0.35   95    0    0    0   0
 96   30500.   5303.   34955.  0.022   0.58      0.68    6.6     48   96  |  96    0.0  0.34   96    0    0    0   0
 97   17080.   4200.   23655.  0.022   1.05      0.28    5.6     52   97  |  97    0.0  0.34   97    0    0    0   0
 98   10950.   4037.   20912.  0.022   0.50      0.17    5.2     55   98  |  98    0.0  0.33   98    0    0    0   0
 99   36630.   8160.  111387.  0.022   0.49      1.70   13.7     57   99  |  99    0.0  0.34   99  100    0    0   0
100   24650.   8160.   30444.  0.022   0.77      0.72    3.7     99  100  | 100    0.0  0.34  100    0    0    0   0
101   32250.   4778.   46728.  0.022   0.56      0.10    9.8     60  101  | 101    0.0  0.33  101    0    0    0   0
102   37000.   4100.   40002.  0.022   0.55      0.00    9.6     61  102  | 102    0.0  0.33  102    0    0    0   0
103   26310.   4792.   32453.  0.022   0.69      0.10    6.8     60  103  | 103    0.0  0.33  103    0    0    0   0
104   16140.   5740.   44404.  0.022   1.12     -0.07    7.7     63  104  | 104    0.0  0.32  104    0    0    0   0
105    3300.    300.    3221.  0.028   5.45    -19.99   10.7     76   77  | 105    0.0  0.40  106  107    0    0   0
106    3165.    300.    3028.  0.028   5.69    -20.00   10.1     77  105  | 106    0.0  0.40  107  108    0    0   0
107    2770.    250.    3053.  0.028   6.50    -20.00   12.2    105  106  | 107    0.0  0.40  108  109    0    0   0
  8    2640.    250.    1797.  0.029   5.67    -20.01    7.4    106  107  | 108  -20.1  0.40  109    0    0    0   0
```

```
111   3400.   930.   19491.  0.024   5.29      0.01   21.0    109   110  I  111      0.0  0.40   112    0    0    0   0
112   3500.   900.   20662.  0.024   5.16     -0.00   23.0    110   111  I  112      0.0  0.39   113  114    0    0   0
113   3200.    90.     937.  0.035   5.63     -0.30   10.4     73   112  I  113      0.0  0.38   114  115    0    0   0
114   6200.    50.     477.  0.035   4.29     -0.31    9.5    112   113  I  114  -1500.0  0.41     1    0    0    0   0
115   2700.    70.     198.  0.035   6.67      0.31    2.8     76   113  I  115      0.0  0.40   116  117    0    0   0
116   2350.  3000.   14959.  0.035   5.37      0.08    5.0     63   115  I  116      0.0  0.40   117  118    0    0   0
117   2650.  3200.   15663.  0.035   6.32      0.06    4.9    115   116  I  117      0.0  0.40   118  119    0    0   0
118   1850.  2200.    9440.  0.035   9.77      0.04    4.3    116   117  I  118      0.0  0.40   119    0    0    0   0
119   1400.  1200.    2640.  0.035  12.16      0.02    2.2    117   118  I  119      0.0  0.40   120  121    0    0   0
120   4300.  4000.   26574.  0.035   4.19      0.24    5.6     65   119  I  120      0.0  0.40   121  122  125    0   0
121   2500.  4050.   26482.  0.035   7.20      0.17    5.5    119   120  I  121      0.0  0.39   122  123    0    0   0
122   3000.  2000.    7266.  0.035   6.00      0.08    3.6    120   121  I  122      0.0  0.39   123  124    0    0   0
123   2200.  1600.    3582.  0.035   9.18      0.04    2.2    121   122  I  123      0.0  0.39   124    0    0    0   0
124   2300.   500.    1417.  0.035   9.00      0.01    2.8    122   123  I  124      0.0  0.40   125  126    0    0   0
125   2750.  3000.   13907.  0.035   6.55      0.08    4.6    120   124  I  125      0.0  0.40   126  127    0    0   0
126   2000.  1200.    5197.  0.035   5.07      0.04    4.3    124   125  I  126      0.0  0.39   127    0    0    0   0
127   2700.   400.     896.  0.035   6.92      0.01    2.2    125   126  I  127      0.0  0.39   128  129  130    0   0
128   5500.  4500.   27806.  0.035   3.40    237.15    6.2     87   127  I  128      0.0  0.40   129    0    0    0   0
129   5000.   750.    2241.  0.035   2.00      0.10    3.0    127   128  I  129      0.0  0.40    13  131  132    0   0
130  12500.  2700.    8344.  0.035   1.44   -236.97    3.1     36   127  I  130      0.0  0.40   131  133  134    0   0
131   2490.  1600.   25734.  0.017   7.23   1106.75   14.3    129   130  I  131   -450.0  0.40   132  133  135    0   0
132   2611.   900.    8364.  0.020   6.97    413.13    9.3    129   131  I  132      0.0  0.40   135  136  137  139   0
133   1600.  1650.   12039.  0.020  10.00    -49.31    7.3    130   131  I  133      0.0  0.40   137    0    0    0   0
134   2490.  2000.   32594.  0.017   0.0   -1156.07   16.3     14   130  I
135   2530.  1350.    7149.  0.020   0.0     913.80    5.3    131   132  I
136   2280.  2700.   11604.  0.020   0.0     -16.83    4.3     14   132  I
137   2700.  1500.    6444.  0.022   0.0       0.01    4.3    132   133  I
138   3750.  1800.   13160.  0.020   0.0    -796.86    7.3     79   132  I
139   4140.  2250.   16508.  0.020   0.0     586.23    7.3     79    80  I


               ***************   DIFFUSION CONSTANTS   ***************

                 CHANNEL    CHANNEL          CONSTANT (C4)
               ---------------------------------------------------

                    1          45             25.00
                   46         133             10.00
```

```
******************************     SUMMARY OF UPPER BOUNDARY CONDITIONS  (NODE 114)     ******************************

 INCREMENT              CONSTITUENT 1      CONSTITUENT 2      CONSTITUENT 3      CONSTITUENT 4      CONSTITUENT 5      CONSTITUENT 6
NO. LENGTH    FLOW     CONC.     LOAD     CONC.     LOAD     CONC.     LOAD     CONC.     LOAD     CONC.     LOAD     CONC.     LOAD
   (CYCLES)   (CFS)   (MG/L)  (LB/DAY)   (MG/L)  (LB/DAY)   (MG/L)  (LB/DAY)   (UG/L)  (LB/DAY)   (MG/L)  (LB/DAY)   (MG/L)  (LB/DAY)
----------------------------------------------------------------------------------------------------------------------------------------

 1    500   -1500.    0.20     1516.    0.20      1618.



     **********************************     SUMMARY OF INITIAL CONCENTRATIONS     **********************************

               FROM      TO     CONST 1     CONST 2     CONST 3     CONST 4     CONST 5     CONST 6
               JUNC     JUNC     (MG/L)      (MG/L)      (MG/L)      (UG/L)      (MG/L)      (MG/L)
          ----------------------------------------------------------------------------------------

                  1       10      0.10        0.10

                 11       20      1.00        1.00

                 21      128      0.10        0.10

                129      133      1.00        1.00
```

```
****************************************   SUMMARY OF CONSTITUENT DECAY RATES   ****************************************

                         CONST 1       CONST 2       CONST 3 *      CONST 4       CONST 5       CONST 6
   FROM       TO       (DECAYK 1)    (DECAYK 2)    (DECAYK 3)    (DECAYK 4)    (DECAYK 5)    (DECAYK6)
   JUNC      JUNC       (PER DAY)     (PER DAY)     (PER DAY)     (PER DAY)     (PER DAY)     (PER DAY)
   ---------------------------------------------------------------------------------------------------------

      1         1         0.030          0.0
      2        20         0.070          0.0
     21       113         0.030          0.0
    114       114         0.070          0.0
    115       128         0.030          0.0
    129       130         0.070          0.0
    131       133         0.030          0.0

*  CONSTITUENT 3 UNDERGOES 2ND ORDER DECAY



     ******************************   SUMMARY OF CONSTANT WASTEWATER  LOADS   ******************************

JUNC.   TOTAL FLOW    CONSTITUENT 1     CONSTITUENT 2     CONSTITUENT 3     CONSTITUENT 4     CONSTITUENT 5     CONSTITUENT 6
          (CFS)      CONC.    LOAD     CONC.    LOAD     CONC.    LOAD     CONC.    LOAD     CONC.    LOAD     CONC.    LOAD
                    (MG/L) (LB/DAY)   (MG/L) (LB/DAY)   (MG/L) (LB/DAY)   (UG/L) (LB/DAY)   (MG/L) (LB/DAY)   (MG/L) (LB/DAY)
-------------------------------------------------------------------------------------------------------------------------------
131      -450.0        4.0    9709.      0.5    1214.
```

```
**********************************     SUMMARY OF DISSOLVED OXYGEN (CONSTITUENT 6)  RATES     **********************************

                                    PHOTOSYNTHESIS     RESPIRATION     PHOTIC DEPTH     BENTHIC DEMAND
             FROM        TO             (PHOT)            (RES)           (DEPTH)           (BENT)
             JUNC       JUNC               (MG/HR/UG CHLORO)              (FEET)
          ---------------------------------------------------------------------------------------------

               0          0         0.0               0.0              0.0              0.0



**********************************     SUMMARY OF NUTRIENT UPTAKE AND REGENERATION RATES     **********************************

        FROM       TO      CONST 1 UPTAKE     CONST 3 UPTAKE     CONST 1 REGEN     CONST 3 REGEN     CONST 5 REGEN
        JUNC      JUNC        (AMUPP)            (PHUPP)            (REGENN)          (REGEPP)          (REBOD)
      ------------------------------------------------------------------------------------------------------------------

          1        133         0.0                0.0                0.0               0.0               0.0
```

```
***********************************   TIDAL CYCLE VARIATION OF SEAWARD BOUNDARY CONDITIONS   ******************************


                                     SPECIFIED CONCENTRATIONS AT JUNCTION 1

         INTERVAL     CONSTITUENT 1     CONSTITUENT 2     CONSTITUENT 3     CONSTITUENT 4     CONSTITUENT 5     CONSTITUENT 6
                          (MG/L)            (MG/L)            (MG/L)            (UG/L)            (MG/L)            (MG/L)
--------------------------------------------------------------------------------------------------------------------------------

             1             0.10              0.10
             2             0.10              0.10
             3             0.10              0.10
             4             0.10              0.10
             5             0.10              0.10
             6             0.10              0.10
             7             0.10              0.10
             8             0.10              0.10
             9             0.10              0.10
            10             0.10              0.10
            11             0.10              0.10
            12             0.10              0.10
            13             0.10              0.10
            14             0.10              0.10
            15             0.10              0.10
            16             0.10              0.10
            17             0.10              0.10
            18             0.10              0.10
            19             0.10              0.10
            20             0.10              0.10
            21             0.10              0.10
            22             0.10              0.10
            23             0.10              0.10
            24             0.10              0.10
            25             0.10              0.10
```

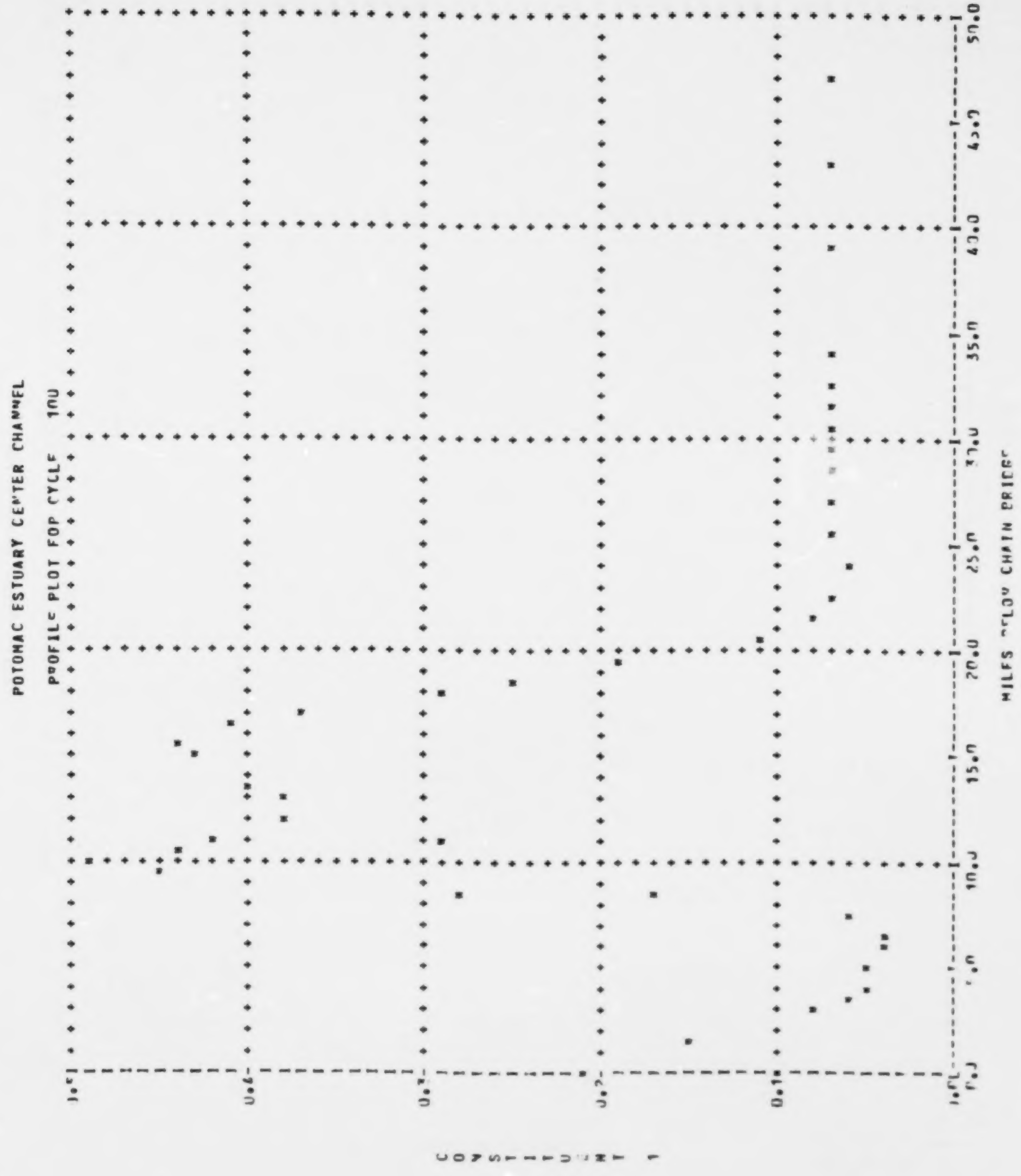
```
                    SYSTEM STATUS AFTER QUALITY CYCLE   108         2 DAYS,   8.00 HOURS

  JUNCTION    HEAD      CONSTITUENT 1     CONSTITUENT 2     CONSTITUENT 3     CONSTITUENT 4     CONSTITUENT 5     CONSTITUENT 6
              (FT)         (MG/L)            (MG/L)            (MG/L)            (UG/L)            (MG/L)            (MG/L)
--------------------------------------------------------------------------------------------------------------------------------
     114      1.80          0.21              0.18
       2      1.79          0.15              0.26
       3      1.79          0.03              0.22
       4      1.79          0.04              0.19
       5      1.79          0.05              0.17
       6      1.79          0.05              0.16
       7      1.78          0.04              0.16
       8      1.78          0.04              0.15
       9      1.77          0.04              0.18
      10      1.76          0.17              0.35
      11      1.75          0.28              0.50
      12      1.74          0.45              0.73
      13      1.74          0.49              0.89
     128      1.73          0.44              1.00
     130      1.72          0.29              1.12
      14      1.71          0.42              1.14
      15      1.69          0.39              1.17
      16      1.67          0.38              1.26
      17      1.65          0.40              1.22
      18      1.63          0.43              1.28
      19      1.61          0.44              1.19
      20      1.59          0.41              1.00
      21      1.57          0.37              0.82
      22      1.54          0.29              0.59
      23      1.53          0.25              0.49
      24      1.50          0.19              0.37
      25      1.47          0.11              0.20
      26      1.44          0.09              0.15
      27      1.41          0.07              0.12
      28      1.36          0.06              0.11
      29      1.30          0.07              0.13
      30      1.26          0.07              0.13
      31      1.21          0.07              0.13
      32      1.18          0.07              0.13
      33      1.15          0.07              0.13
      34      1.12          0.07              0.13
      35      1.08          0.07              0.13
      36      1.02          0.07              0.13
      38      0.85          0.07              0.13
      40      0.70          0.07              0.13
      42      0.57          0.07              0.13
      44      0.40          0.07              0.13
      46      0.16          0.07              0.13
      48     -0.04          0.07              0.13
      50     -0.21          0.07              0.13
      52     -0.29          0.07              0.13
      54     -0.36          0.07              0.13
      56     -0.40          0.07              0.13
      58     -0.42          0.07              0.13
      60     -0.45          0.07              0.13
      62     -0.46          0.07              0.13
```

```
                                              HIGH SLACK PREDICTIONS

 JUNCTION   HEAD      CONSTITUENT 1   CONSTITUENT 2   CONSTITUENT 3   CONSTITUENT 4   CONSTITUENT 5   CONSTITUENT 6
            (FT)         (MG/L)          (MG/L)          (MG/L)          (UG/L)          (MG/L)          (MG/L)
---------------------------------------------------------------------------------------------------------------------------

                                    CYCLE  300          6 DAYS, 12.00 HOURS

     1     -0.41         0.12             0.10
    65     -0.44         0.08             0.12
---------------------------------------------------------------------------------------------------------------------------

                                    CYCLE  301          6 DAYS, 12.50 HOURS

    64     -0.42         0.05             0.15
    63     -0.44         0.04             0.16
    62     -0.45         0.04             0.16
    61     -0.46         0.04             0.16
---------------------------------------------------------------------------------------------------------------------------

                                    CYCLE  302          6 DAYS, 13.00 HOURS

    60     -0.43         0.03             0.17
    59     -0.45         0.03             0.17
    58     -0.47         0.03             0.17
---------------------------------------------------------------------------------------------------------------------------

                                    CYCLE  303          6 DAYS, 13.50 HOURS

    57     -0.42         0.03             0.17
---------------------------------------------------------------------------------------------------------------------------

                                    CYCLE  304          6 DAYS, 14.00 HOURS

    56     -0.33         0.03             0.17
    55     -0.35         0.03             0.17
    54     -0.36         0.03             0.17
---------------------------------------------------------------------------------------------------------------------------

                                    CYCLE  305          6 DAYS, 14.50 HOURS

    53     -0.24         0.03             0.17
    52     -0.26         0.03             0.17
    51     -0.27         0.03             0.17
    50     -0.29         0.03             0.17
    49     -0.31         0.03             0.17
---------------------------------------------------------------------------------------------------------------------------

                                    CYCLE  306          6 DAYS, 15.00 HOURS

    48     -0.23         0.03             0.17
    47     -0.25         0.03             0.17
    46     -0.25         0.03             0.17
    45     -0.24         0.03             0.17
    44     -0.23         0.03             0.17
---------------------------------------------------------------------------------------------------------------------------
```

```
   43     -0.27        0.03          0.17
   42     -0.28        0.03          0.17
   41     -0.27        0.03          0.17
   40     -0.27        0.03          0.17
   39     -0.26        0.03          0.17
   38     -0.26        0.03          0.17
   37     -0.27        0.03          0.17
   36     -0.26        0.03          0.17
--------------------------------------------------------------------------------

                  CYCLE  308          6 DAYS, 16.00 HOURS

   35     -0.40        0.03          0.16
   34     -0.39        0.03          0.16
   33     -0.38        0.03          0.16
   32     -0.38        0.03          0.16
   31     -0.37        0.04          0.18
   30     -0.37        0.05          0.23
   29     -0.36        0.06          0.34
--------------------------------------------------------------------------------

                  CYCLE  309          6 DAYS, 16.50 HOURS

   28     -0.51        0.12          0.73
   27     -0.51        0.13          0.89
   26     -0.50        0.14          0.98
   25     -0.50        0.14          1.11
   24     -0.49        0.14          1.23
   23     -0.49        0.13          1.36
   22     -0.50        0.13          1.35
   21     -0.50        0.14          1.38
   20     -0.49        0.14          1.34
   19     -0.49        0.19          1.26
   18     -0.49        0.23          1.22
   17     -0.46        0.30          1.01
   16     -0.47        0.32          0.81
   15     -0.47        0.24          0.66
   14     -0.46        0.31          0.48
  130     -0.46        0.29          0.50
  129     -0.46        0.15          0.43
   13     -0.46        0.13          0.36
   12     -0.46        0.04          0.25
   11     -0.46        0.01          0.23
   10     -0.46        0.02          0.24
    9     -0.45        0.01          0.23
    8     -0.45        0.03          0.32
    7     -0.45        0.03          0.34
--------------------------------------------------------------------------------

                  CYCLE  310          6 DAYS, 17.00 HOURS

    6     -0.42        0.05          0.35
    5     -0.42        0.06          0.34
    4     -0.42        0.07          0.33
    3     -0.42        0.10          0.31
    2     -0.43        0.14          0.26
  114     -0.42        0.21          0.18
```

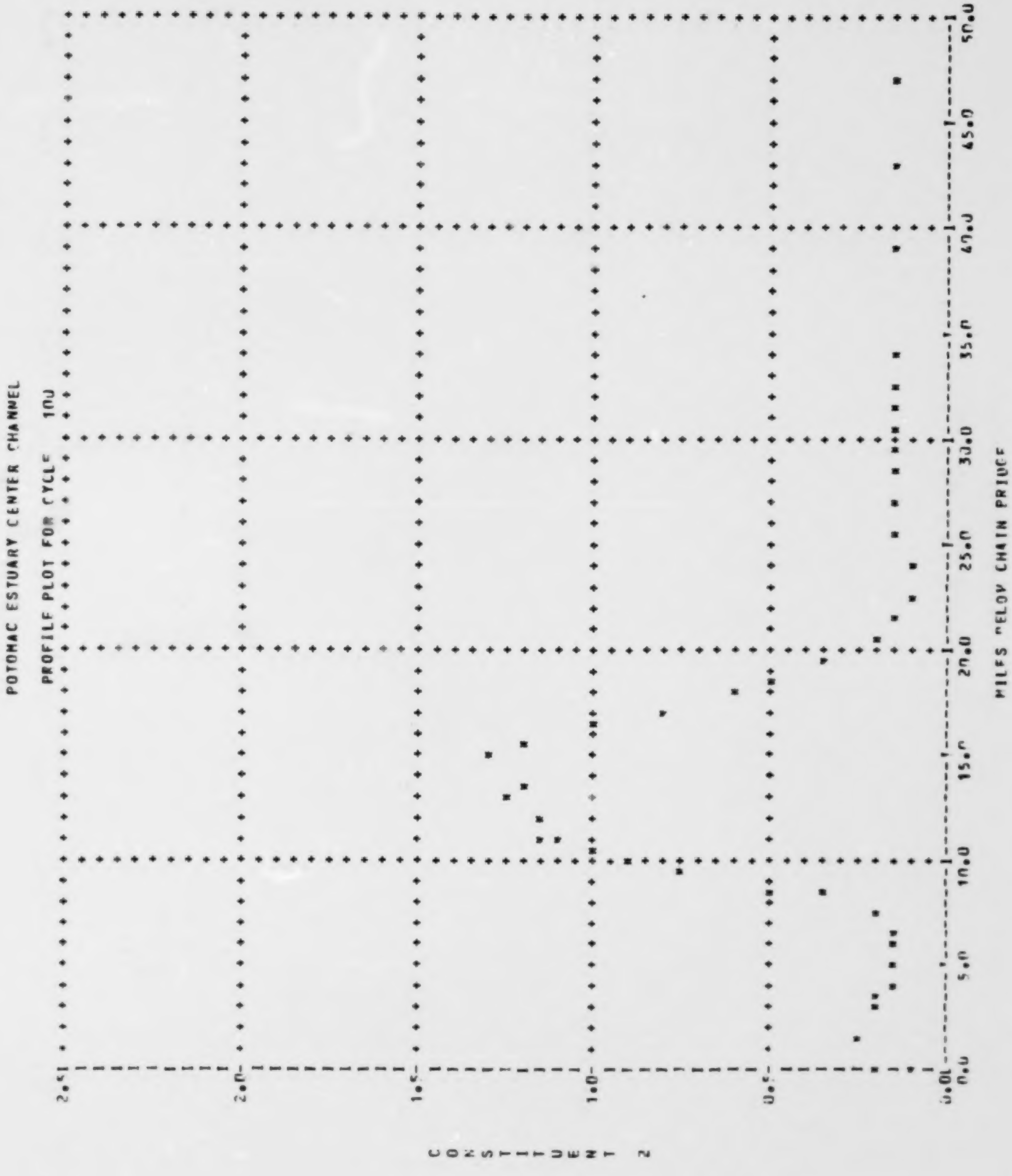
```
                                   LOW SLACK PREDICTIONS

 JUNCTION   HEAD      CONSTITUENT 1   CONSTITUENT 2   CONSTITUENT 3   CONSTITUENT 4   CONSTITUENT 5   CONSTITUENT 6
            (FT)         (MG/L)          (MG/L)          (MG/L)          (UG/L)          (MG/L)          (MG/L)
--------------------------------------------------------------------------------------------------------------------

                               CYCLE  400          8 DAYS, 14.00 HOURS

     1     -0.41         0.10            0.10
    65     -0.44         0.08            0.12
    64     -0.45         0.05            0.15
    63     -0.45         0.03            0.17
    62     -0.46         0.03            0.17
    61     -0.46         0.03            0.17
    60     -0.45         0.03            0.17
--------------------------------------------------------------------------------------------------------------------

                               CYCLE  401          8 DAYS, 14.50 HOURS

    59     -0.47         0.02            0.18
    58     -0.47         0.02            0.18
--------------------------------------------------------------------------------------------------------------------

                               CYCLE  402          8 DAYS, 15.00 HOURS

    57     -0.48         0.02            0.18
--------------------------------------------------------------------------------------------------------------------

                               CYCLE  403          8 DAYS, 15.50 HOURS

    56     -0.44         0.02            0.18
    55     -0.45         0.02            0.18
    54     -0.45         0.02            0.18
--------------------------------------------------------------------------------------------------------------------

                               CYCLE  404          8 DAYS, 16.00 HOURS

    53     -0.38         0.02            0.18
    52     -0.38         0.02            0.18
    51     -0.39         0.02            0.18
    50     -0.36         0.02            0.18
--------------------------------------------------------------------------------------------------------------------

                               CYCLE  405          8 DAYS, 16.50 HOURS

    49     -0.31         0.02            0.18
    48     -0.31         0.02            0.18
    47     -0.27         0.02            0.18
--------------------------------------------------------------------------------------------------------------------

                               CYCLE  406          8 DAYS, 17.00 HOURS

    46     -0.25         0.02            0.18
    45     -0.24         0.02            0.18
    44     -0.23         0.02            0.18
    43     -0.21         0.02            0.18
    42     -0.19         0.02            0.18
```

```
                              CYCLE  407          8 DAYS, 17.50 HOURS

   41     -0.27          0.02            0.18
   40     -0.27          0.02            0.18
   39     -0.26          0.02            0.18
   38     -0.26          0.02            0.18
   37     -0.27          0.02            0.18
   36     -0.26          0.02            0.17
-------------------------------------------------------------------------------------------------------

                              CYCLE  408          8 DAYS, 18.00 HOURS

   35     -0.40          0.02            0.17
   34     -0.39          0.02            0.18
   33     -0.38          0.02            0.19
   32     -0.38          0.03            0.20
   31     -0.37          0.03            0.24
   30     -0.37          0.04            0.33
   29     -0.36          0.05            0.48
-------------------------------------------------------------------------------------------------------

                              CYCLE  409          8 DAYS, 18.50 HOURS

   28     -0.51          0.09            0.93
   27     -0.51          0.09            1.06
   26     -0.50          0.09            1.12
   25     -0.50          0.09            1.22
   24     -0.49          0.09            1.30
   23     -0.49          0.09            1.35
   22     -0.50          0.10            1.35
   21     -0.50          0.11            1.34
   20     -0.49          0.13            1.29
   19     -0.49          0.17            1.20
   18     -0.49          0.21            1.15
   17     -0.48          0.29            0.94
-------------------------------------------------------------------------------------------------------

                              CYCLE  410          8 DAYS, 19.00 HOURS

   16     -0.64          0.32            0.71
   15     -0.64          0.24            0.58
   14     -0.63          0.30            0.47
  130     -0.63          0.25            0.49
  129     -0.63          0.13            0.42
   13     -0.63          0.11            0.36
   12     -0.63          0.03            0.29
   11     -0.63          0.01            0.29
   10     -0.63          0.02            0.30
    9     -0.63          0.01            0.29
    8     -0.63          0.03            0.30
    7     -0.63          0.04            0.27
-------------------------------------------------------------------------------------------------------

                              CYCLE  411          8 DAYS, 19.50 HOURS

    6     -0.78          0.05            0.76
    5     -0.78          0.04            0.74
    4     -0.78          0.07            0.77
    3     -0.73          0.10            0.71
```



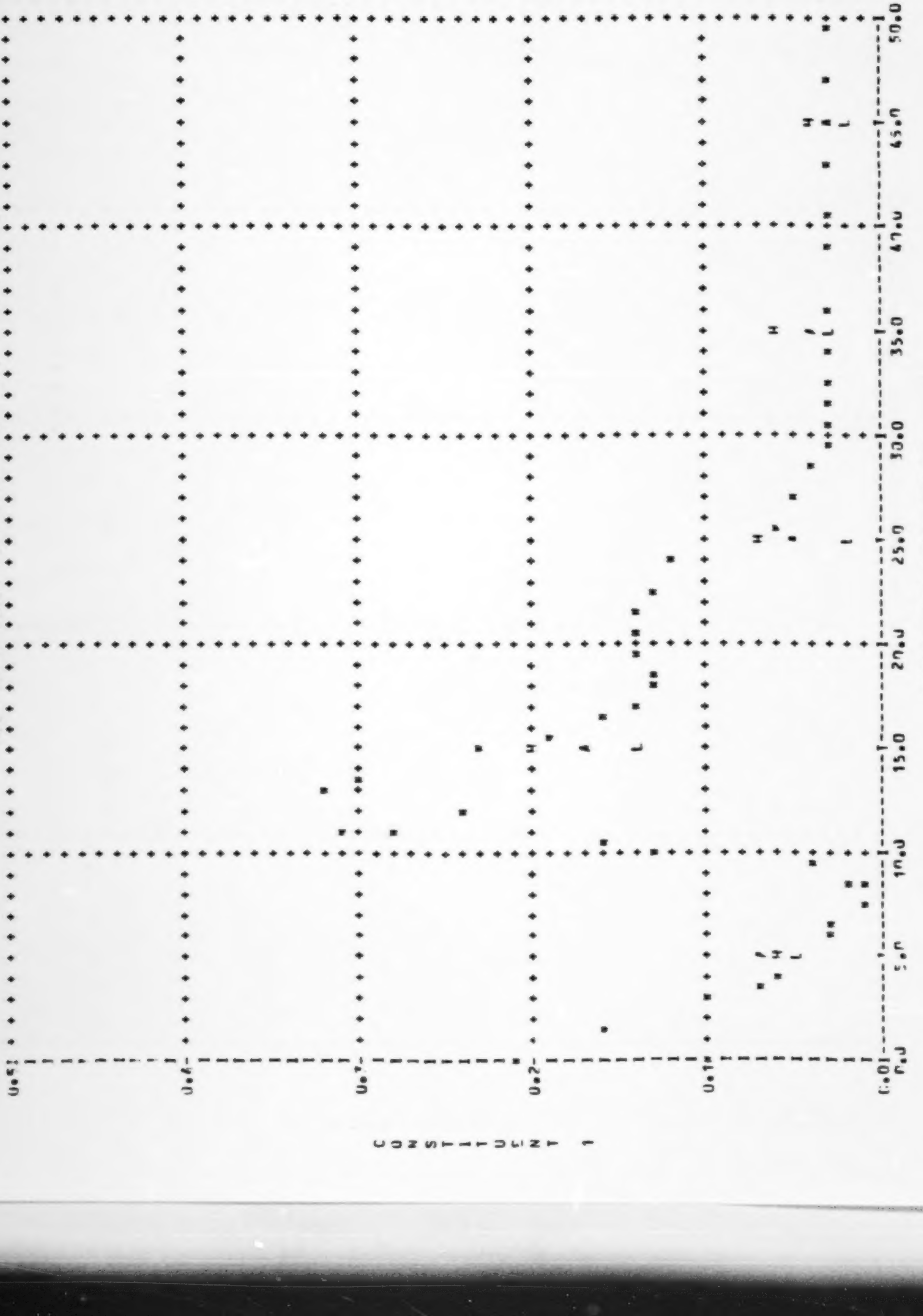
POTOMAC ESTUARY CENTER CHANNEL

PROFILE PLOT FOR CYCLE 100


POTOMAC ESTUARY CENTER CHANNEL
PROFILE PLOT FOR CYCLE 100
MILES BELOW CHAIN BRIDGE
CONSTITUENT 2
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
0.00
0.5
1.0
1.5
2.0
2.5

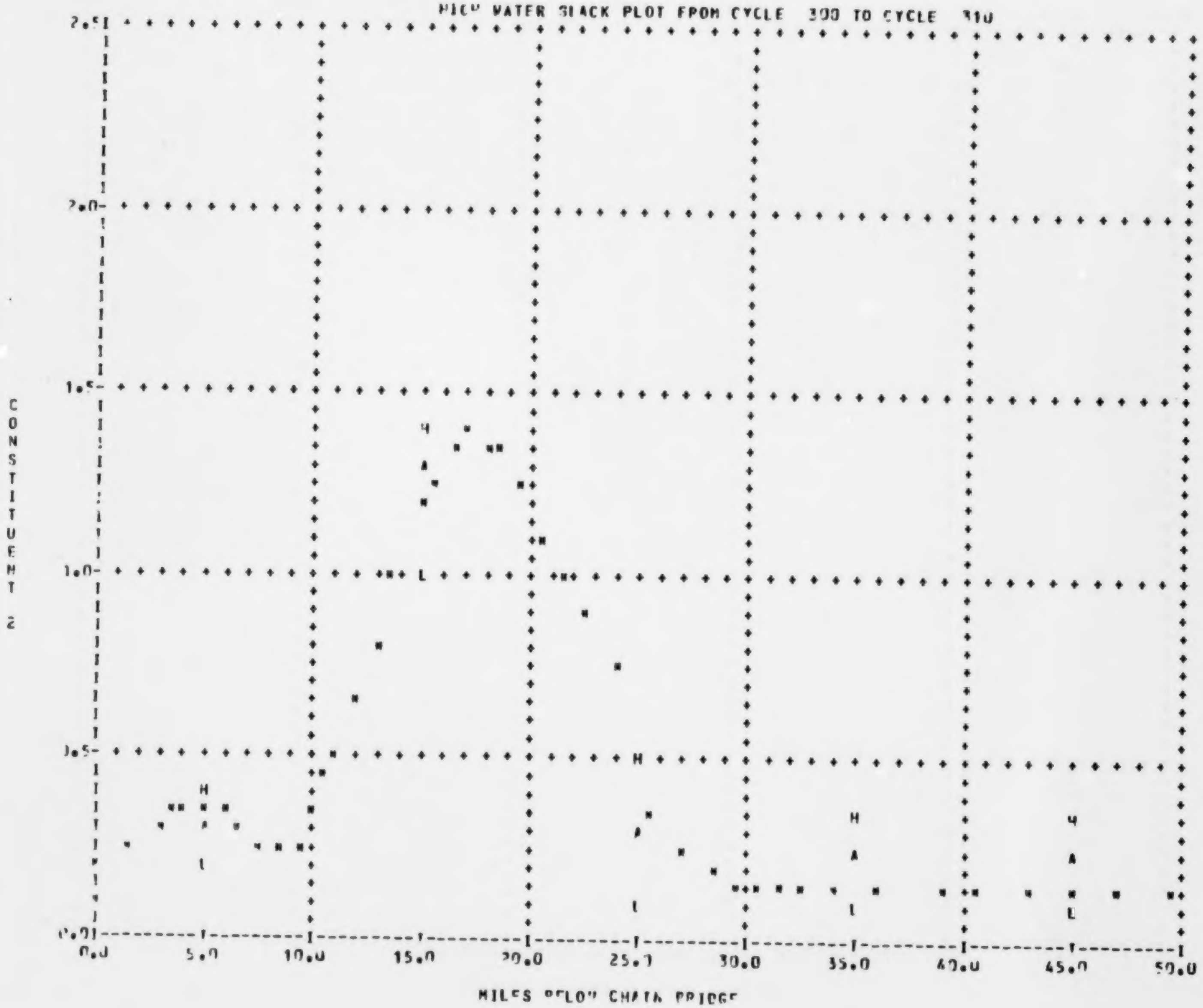
POTOMAC ESTUARY CENTER CHANNEL

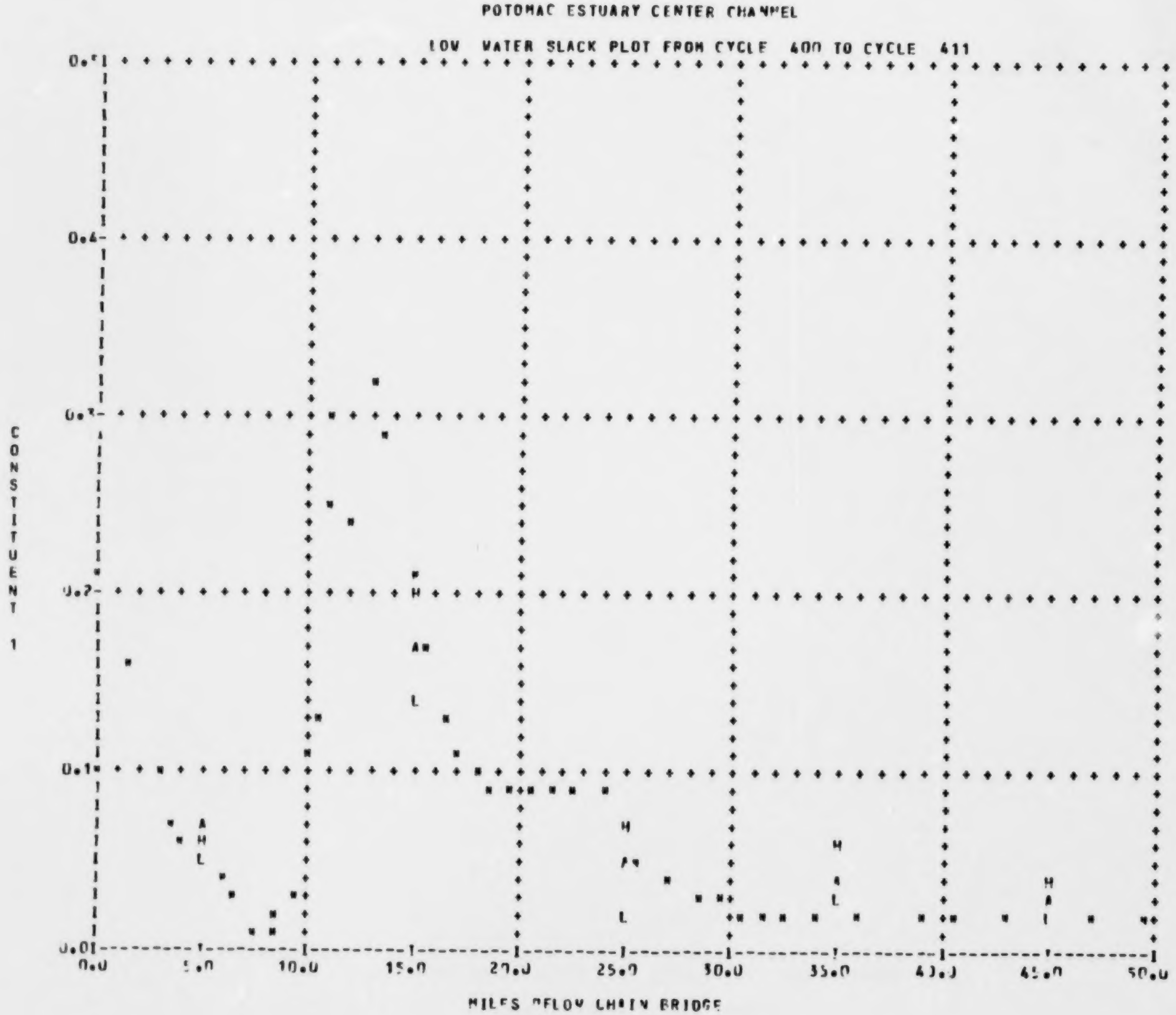
HIGH WATER SLACK PLOT FROM CYCLE 300 TO CYCLE 310

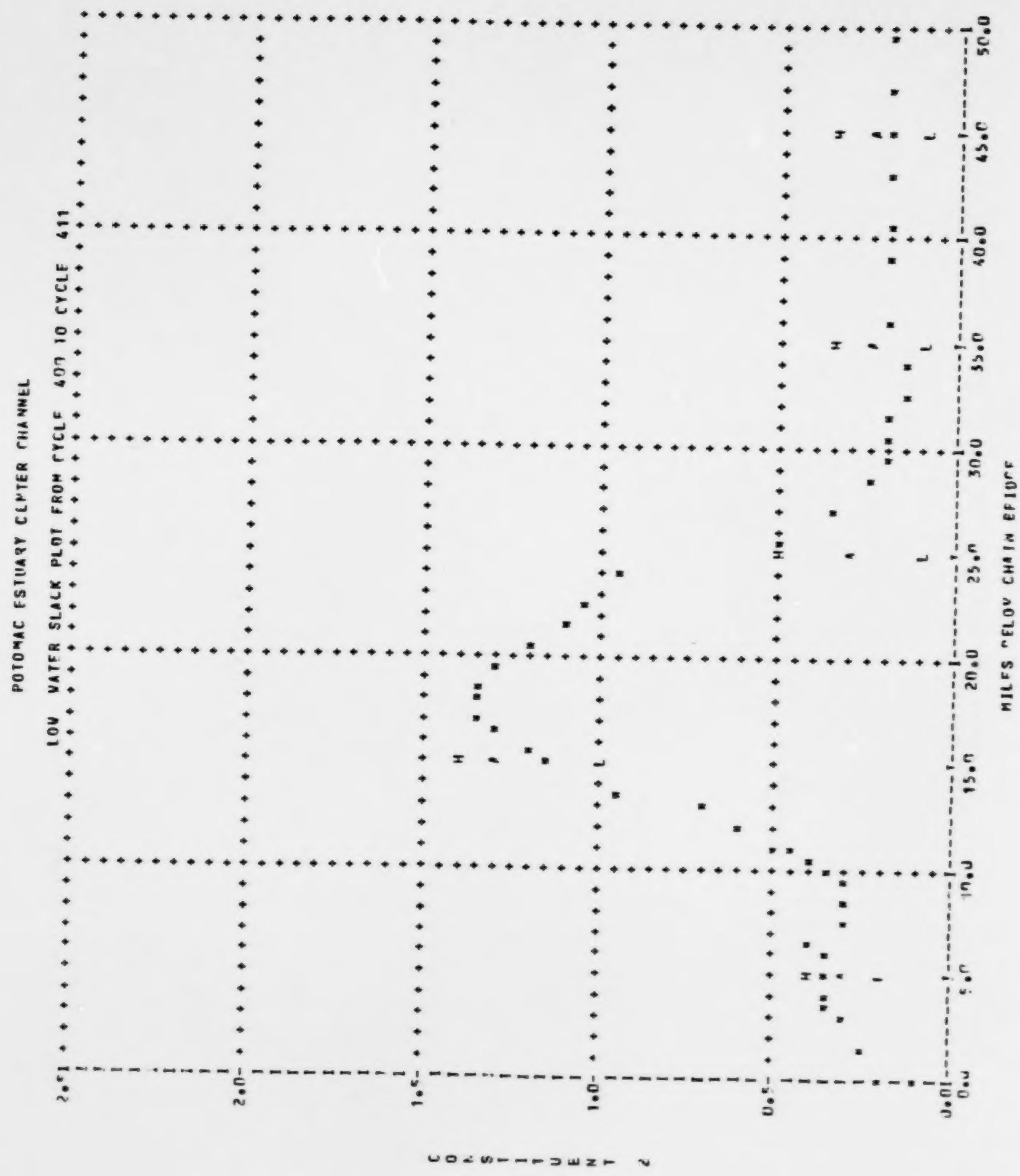


POTOMAC ESTUARY CENTER CHANNEL

HIGH WATER SLACK PLOT FROM CYCLE 300 TO CYCLE 310




POTOMAC ESTUARY CENTER CHANNEL
LOW WATER SLACK PLOT FROM CYCLE 400 TO CYCLE 411
CONSTITUENT 1
0.5
0.4
0.3
0.2
0.1
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
MILES BELOW CHAIN BRIDGE
H
A
L


POTOMAC ESTUARY CENTER CHANNEL
LOW WATER SLACK PLOT FROM CYCLE 407 TO CYCLE 411
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
MILES BELOW CHAIN BRIDGE
0.0
0.5
1.0
1.5
2.0
2.5
CONSTITUENT 2
H
L

4.4.3 6 CONSTITUENT D.O. BUDGET

-- data deck listing --

```
DYNQUAL - SAMPLE RUN 3  -  THIS RUN SIMULATES THE D.O. BUDGET (INCLUDING
                           ALGAL EFFECTS) IN THE POTOMAC ESTUARY
  133  139 1500 2000   20
INDEPENDENT CONTROL DATA - RUN 3
 1500 1000  500  500   25
    6    0    3    4
       30.       6.00
TABULAR OUTPUT CONTROL - RUN 3
    1
  500 1000    0
    1    1
    1 1000    1
    2
  480    1    3
  492    2    4
PLOTTING OUTPUT CONTROL - RUN 3
    0    2    0
    0    0
    0    0    0    0    0    1
   4.   0.   3.   0.   4.   0. 150.   0.  10.   0.  10.   0.
QUALITY COEFFICIENTS - RUN 3
       .25        90.       300.        20.
      .001       1.00       100. NH3
      .001       1.00       100. NO2NO3
      .001       1.00       100. TPO4
      1.00       1.00       500. CHLORO
      .001      1.047       100. CBOD
      .001      1.021       100. DO
DISSOLVED OXYGEN COEFFICIENTS
      6.00      18.00
    9
         1          1       .012      .0008        2.0        1.0
         2          4       .012      .0008        3.5        1.0
         5         17       .012      .0008        2.0        2.0
        18         27       .012      .0008        2.0        1.5
        28        113       .012      .0008        2.0        1.0
       114        114       .012      .0008        3.5        1.0
       115        128       .012      .0008        2.0        1.0
       129        130       .012      .0008        2.0        2.0
       131        133       .012      .0008        2.0        1.0
    1
DIFFUSION CONSTANTS - RUN 3
    1
         1        133        25.
UPTAKE / REGENERATION RATES - RUN 3
    1
         1        133         0.        .01         0.         0.         0.
DECAY RATES - RUN 3
    5
         1          1        .15        .09        .03        .02        .17
         2          8        .05        .09        .03        .02        .10
         9        113        .15        .09        .03        .02        .17
       114        114        .05        .09        .03        .02        .10
       115        133        .15        .09        .03        .02        .17
WASTEWATER INPUTS - RUN 3
    1    0    1
CONSTANT INPUTS
       131      -450.        20.         0.        25.         0.        35.         2.
BANK INPUTS
 16.1  1.8  1.8  1.3  1.3  1.6  3.2  1.6  1.6   .8   .9  1.2   .9   .6   .5  0.0
```

```
   .6  1.6   .9  1.6  3.4   .9   .9  1.9  1.9  1.9  1.5  2.3  4.4  2.7  2.4  2.2
  1.9  2.2  2.0  1.8  3.8  3.5  4.4  5.4  4.1  3.5  3.5  5.7  5.1  5.1  4.4  4.4
  3.6  3.6   .6  2.2 11.4  4.1  2.7  3.8  2.9  4.7  5.7  4.9  1.1  2.1  2.5  4.1
  5.2   .9   .6   .9  1.0  1.1  1.3  1.1   .9  1.6  2.0   .9  2.2  2.1   .8  2.5
  2.5  2.6  1.6  2.8  3.1  1.9  2.7  6.6  2.5 12.8  4.3  5.4 13.3 15.8 15.5 13.7
  3.5 13.9 25.3 12.6 21.5 19.9 21.5 12.6  1.2  1.0  1.0  1.0  1.5  1.3   .9  1.6
  2.0  3.0  1.6   .9   .6   .6  1.1   .5   .9   .8   .3   .9   .9  1.3  1.9  1.6
   .6   .5   .4   .4  1.2
   10   20  100  106
    -100.         10.        5.        15.        0.        30.        0.
UPPER BOUNDARY CONDITIONS - RUN 3
    2
        200    -1500.       .10        .30        .20       25.0        4.0        6.0
        800    -1500.       .05        .20        .10       20.0        3.0        7.1
INITIAL CONDITIONS - RUN 3
          1          1      .01        .10        .10       10.0        1.0        8.0
          2          5      .05        .20        .10       30.0        1.5        6.8
          6          9      .40        .25        .70       30.0        1.7        6.8
         10         15     1.85        .50       2.50       35.0        5.0        1.0
         16         20     1.30       1.60       1.60       70.0        7.0        2.5
         21         25      .70       1.50       1.20       85.0        6.5        3.5
         26         30      .10       1.00        .70       70.0        5.0        5.5
         31         35      .04        .30        .40       65.0        3.0        6.8
         36         40      .02        .60        .40       65.0        1.5        6.8
         41         45      .01        .30        .60       30.0        1.0        8.0
         46         65      .01        .10        .60       10.0        1.0        8.0
         66         77     1.40        .45       2.10       30.0        2.5        2.8
         78         82     1.50       1.00       2.50       65.0        5.0        1.0
         83         85      .40       1.40       2.00       75.0        6.0        5.0
         86        128      .30        .20       1.00       30.0        1.5        6.0
        129        130     1.90        .35       2.80       30.0        4.5         .5
        131        133     1.50       1.00       2.50       65.0        5.0        1.0
SEAWARD BOUNDARY CONDITIONS - RUN 3
    1    1    1    1    1    1
  .05
  .10
  .20
 10.0
  1.0
  8.0
```

```
POTOMAC ESTUARY HYDRAULICS  -  133 JUNCTION NETWORK
FLOW = 1500 CFS AT CHAIN BRIDGE, 450 CFS AT BLUE PLAINS, 0 AT OTHER STP'S                 ENVIRONMENTAL PROTECTION AGENCY
DYNQUAL - SAMPLE RUN 3  -  THIS RUN SIMULATES THE D.O. BUDGET (INCLUDING                    DYNAMIC ESTUARY MODEL
                           ALGAL EFFECTS) IN THE POTOMAC ESTUARY

 ************************   HYDRAULIC CONTROL DATA   ************************

 FIRST CYCLE ON    LAST CYCLE  ON     BEGIN READING TAPE      HYDRAULIC
 HYDRAULIC TAPE    HYDRAULIC TAPE          AT CYCLE        TIME STEP (SEC.)
    (NSTART)          (NSTOP)              (HYDCYC)              (DELT)

      1500              2000                 1500                 90.00

 ********************************************   QUALITY CONTROL DATA   ********************************************

         NUMBER OF         NUTRIENT LIMITATION        D.O. SUMMARY            QUALITY             QUALITY STEPS
      QUALITY CYCLES    SUMMARY BEGINS AT CYCLE     BEGINS AT CYCLE      TIME STEP (HRS)      PER TIDAL PERIOD
         (NQCYC)              (NUTCYC)                 (NDOCYC)              (DELTQ1)              (NSPEC)

          1000                   500                     500                   0.50                  25

 NUMBER OF                          STARTING TIME      TIME OF     TIME OF     D.O. SATURATION
 CONSTITUENTS      TEMPERATURE      FOR THIS RUN       SUNRISE     SUNSET       AT 30.00  C
  (NUMCON)           (TEMP)            (STIME)         (TSRISE)    (TSSET)        (CSAT)

     6               30.00              6.00             6.00       18.00         7.437


 CONSTITUENT     CONSTITUENT      BACKGROUND        TEMPERATURE
   NUMBER           NAME         CONCENTRATION    CORRECTION FACTOR
                  (CNAME)           (BACKC)           (THETA)

      1           NH3               0.001             1.000
      2           NO2NO3            0.001             1.000
      3           TPO4              0.001             1.000
      4           CHLORO            1.000             1.000
      5           CBOD              0.001             1.047
      6           DO                0.001             1.021

                                                                           PERCENT OF DECAYED ALGAE
CHLOROPHYLL/NITROGEN     CHLOROPHYLL/PHOSPHOROUS    CHLOROPHYLL/CARBON     WHICH IS BIO-DEGRADABLE
      (CHLNIT)                 (CHLPHO)                 (CHLCAR)                  (PERCD)

       90.00                    300.00                   27.00                    0.25

 THE REOXYGENATION CONSTANT FOR D.O. IS COMPUTED USING THE O-CONNOR-DOBBINS EQUATION : K2 = 12.9 * V**.5 / H**1.5
 NITROGEN AND PHOSPHOROUS UPTAKE BY ALGAE IS CONSIDERED  (KREAC = 3)
 CONSTITUENT CONCENTRATIONS IN ADVECTED WATER ARE COMPUTED USING THE 1/4 POINT CONCENTRATION  (MIX=4)
 50    9621.  10325.  251552.  0.014   4.58   1943.60   24.4      50    51   I   50     0.0  0.34    49   50    0    0    0
 51    6441.  17714.  347154.  0.014   5.90   1943.13   19.6      51    52   I   51     0.0  0.34    50   51    0    0    0
 52   10561.  25490.  659412.  0.014   4.26   1942.95   18.0      52    53   I   52     0.0  0.34    51   52   97    0    0
 53    9451.  21717.  402421.  0.014   4.76   1942.44   18.5      53    54   I   53     0.0  0.34    52   53    0    0    0
 54    6511.  28187.  434251.  0.014   5.61   1941.60   18.0      54    55   I   54     0.0  0.34    53   54    0    0    0
 55   10665.  30413.  556047.  0.014   4.27   1942.11   18.3      55    56   I   55     0.0  0.34    54   55   98    0    0
 56   10137.  31129.  625965.  0.014   6.44   1942.17   20.1      56    57   I   56     0.0  0.34    55   56    0    0    0
 57    8717.  33034.  658347.  0.014   5.17   1940.47   19.9      57    58   I   57     0.0  0.34    56   57   99    0    0
 58   12302.  27018.  568689.  0.014   3.66   1940.15   21.0      58    59   I   58     0.0  0.34    57   58    0    0    0
 59   10412.  25500.  524251.  0.014   4.24   1940.20   20.6      59    60   I   59     0.0  0.34    58   59    0    0    0
 60   11616.  29075.  574128.  0.014   3.87   1939.67   19.7      60    61   I   60     0.0  0.33    59   60  101  103    0
 61    6705.  28458.  402987.  0.014   6.71   1939.23   21.3      61    62   I   61     0.0  0.33    60   61  102    0    0
 62    8712.  27576.  606865.  0.014   5.17   1939.51   21.5      62    63   I   62     0.0  0.33    61   62    0    0    0
 63    8659.  25729.  625313.  0.014   5.20   1939.42   24.3      63    64   I   63     0.0  0.33    62   63  104    0    0
 64    8650.  24364.  690297.  0.014   5.20   1939.30   27.9      64    65   I   64     0.0  0.33    63   64    0    0    0
 65   16104.  22510.  733238.  0.014   2.79  -1939.10   32.6       1    65   I   65     0.0  0.33    64   65    0    0    0
 66    2600.   3200.   61256.  0.024  17.31    -19.91   19.1       9    66   I   66     0.0  0.40    66   67  110    0    0
 67    2640.   1500.   31398.  0.024  17.05    -20.04   20.9      66    67   I   67     0.0  0.40    67   68    0    0    0
 68    2380.   1250.   27185.  0.024  18.91    -20.04   21.7      67    68   I   68     0.0  0.40    68   69    0    0    0
 69    2510.   1250.   27182.  0.024  17.93    -20.03   21.7      68    69   I   69     0.0  0.40    69   70    0    0    0
 70    2640.   1150.   24786.  0.024  17.05    -20.03   21.6      69    70   I   70     0.0  0.40    70   71    0    0    0
 71    7035.    750.   14488.  0.024  14.83    -20.02   19.3      70    71   I   71     0.0  0.40    71   72    0    0    0
 72    3430.    750.    8618.  0.024  13.12    -20.02   11.5      71    72   I   72     0.0  0.40    72   73    0    0    0
 73    3300.    750.    8681.  0.024  13.64    -20.01   11.6      72    73   I   73     0.0  0.40    73   74  113    0    0
 74    3035.    550.    3149.  0.026  14.83    -19.69    5.7      73    74   I   74     0.0  0.40    74   75    0    0    0
 75    3430.    400.    4805.  0.026  13.12    -19.69   12.0      74    75   I   75     0.0  0.40    75   76    0    0    0
 76    3565.    350.    2870.  0.026  12.62    -19.69    8.2      75    76   I   76     0.0  0.40    76  105  115    0    0
 77    4630.   1311.   16144.  0.022   9.32      0.01   12.3      12    78   I   77     0.0  0.40   105  106    0    0    0
 78    2100.   4500.   19478.  0.020  21.43   -210.55    4.3      15    79   I   78     0.0  0.40    77    0    0    0    0
 79    3450.   4400.   30863.  0.020  13.04   -586.20    7.3      16    80   I   79     0.0  0.40    78  138  139    0    0
 80    2405.   6231.   21119.  0.022  13.22      0.03    3.4      16    81   I   80     0.0  0.40    79  139    0    0    0
 81    5550.   2922.   12456.  0.022   9.11      0.04    4.3      19    82   I   81     0.0  0.40    80    0    0    0    0
 82    3700.   3412.   13886.  0.022  12.16      0.12    4.1      23    83   I   82     0.0  0.40    81    0    0    0    0
 83    4320.   4140.   12598.  0.022  10.42      0.06    3.0      27    84   I   83     0.0  0.40    82  116    0    0    0
 84   10530.   4214.   24678.  0.022   4.27      0.56    4.0      28    85   I   84     0.0  0.40    83    0    0    0    0
 85    6250.   8000.   40765.  0.022   7.20   -314.21    5.1      34    86   I   85     0.0  0.40    84  120    0    0    0
 86   10090.   7250.   59191.  0.022   4.50    552.80    8.2      35    87   I   86     0.0  0.39    85   87   68    0    0
 87    7550.   9930.   72642.  0.022   6.12   -315.33    7.3      66    87   I   87     0.0  0.39    86   87  128    0    0
 88   12855.   5401.   25708.  0.022   3.50      0.54    4.6      66    88   I   88     0.0  0.39    88    0    0    0    0
 89    8190.   2347.    6229.  0.022   5.49      0.15    2.7      36    89   I   89     0.0  0.39    89    0    0    0    0
 90   16200.   4601.   39860.  0.022   2.79      0.57    8.7      36    90   I   90     0.0  0.39    90    0    0    0    0
 91    6450.   3531.    9184.  0.022   6.98      0.17    2.6      37    91   I   91     0.0  0.39    91    0    0    0    0
 92   12180.   2408.    8665.  0.022   3.60      0.24    3.5      38    92   I   92     0.0  0.38    92    0    0    0    0
 93   26700.   3786.   17163.  0.022   1.60      0.93    4.5      42    93   I   93     0.0  0.37    93    0    0    0    0
 94   22410.   3435.   12156.  0.022   2.01      0.65    3.5      43    94   I   94     0.0  0.37    94    0    0    0    0
 95   24610.   5027.   17999.  0.022   1.61      0.83    3.6      47    95   I   95     0.0  0.35    95    0    0    0    0
 96   30900.   5303.   34955.  0.022   1.46      0.66    4.6      46    96   I   96     0.0  0.34    96    0    0    0    0
 97   17080.   4200.   23655.  0.022   2.63      0.25    5.6      52    97   I   97     0.0  0.34    97    0    0    0    0
 98   19950.   4037.   20912.  0.022   2.26      0.17    5.2      55    98   I   98     0.0  0.33    98    0    0    0    0
 99   36830.   9160.  111387.  0.022   1.27      1.70   13.7      57    99   I   99     0.0  0.34    99  100    0    0    0
100   24650.   8160.   30444.  0.022   1.83      0.72    3.7      99   100   I  100     0.0  0.34   100    0    0    0    0
101   32250.   4778.   66778.  0.022   1.47      0.10    9.8      60   101   I  101     0.0  0.33   101    0    0    0    0
102   38000.   4100.   60002.  0.022   1.36      0.00    9.8      61   102   I  102     0.0  0.33   102    0    0    0    0
103   26310.   4792.   32453.  0.022   1.71      0.10    6.8      60   103   I  103     0.0  0.33   103    0    0    0    0
104   16140.   5740.   44474.  0.022   2.70     -0.07    7.7      63   104   I  104     0.0  0.33   104    0    0    0    0
105    3300.    300.    3221.  0.028  13.64    -19.99   10.7      76    77   I  105     0.0  0.40   106  107    0    0    0
106    3165.    300.    3028.  0.028  14.22    -20.00   10.1      77   105   I  106     0.0  0.40   107  108    0    0    0
107    2770.    250.    3053.  0.028  16.25    -20.00   12.2     105   106   I  107     0.0  0.40   108  109    0    0    0
108    2640.    250.    1797.  0.028  17.05    -20.00    7.2     106   107   I  108   -20.0  0.40   109    0    0    0    0
```

```
 111    3400.    630.   19491.  0.036  13.24      0.01    21.0      109    110    I   111      0.0  0.40    112    0    0    0    0
 112    3500.    900.   20652.  0.024  12.66     -0.00    23.0      110    111    I   112      0.0  0.39    113  114    0    0    0
 113    3400.     90.     937.  0.035  14.06     -0.30    19.4       73    112    I   113      0.0  0.38    114  115    0    0    0
 114    4200.     50.     477.  0.035  19.71     -0.31     9.5      112    113    I   114  -1500.0  0.41      1    0    0    0    0
 115    2700.     70.     198.  0.035  16.67      0.31     2.8       76    113    I   115      0.0  0.40    116  117    0    0    0
 116    3350.   3000.   14969.  0.035  13.43      0.08     5.0       83    115    I   116      0.0  0.40    117  118    0    0    0
 117    2350.   3200.   15663.  0.035  15.79      0.06     4.9      115    116    I   117      0.0  0.40    118  119    0    0    0
 118    1650.   2200.    9440.  0.035  24.32      0.04     4.3      116    117    I   118      0.0  0.40    119    0    0    0    0
 119    1480.   1200.    2640.  0.035  30.41      0.02     2.2      117    118    I   119      0.0  0.40    120  121    0    0    0
 120    4500.   4000.   26574.  0.035  10.47      0.24     6.6       85    119    I   120      0.0  0.40    121  122  125    0    0
 121    2500.   4050.   26492.  0.035  18.09      0.17     6.5      119    120    I   121      0.0  0.39    122  123    0    0    0
 122    3000.   2000.    7266.  0.035  15.00      0.08     3.6      120    121    I   122      0.0  0.39    123  124    0    0    0
 123    2200.   1000.    3582.  0.035  20.45      0.06     2.2      121    122    I   123      0.0  0.39    124    0    0    0    0
 124    2000.    500.    1417.  0.035  22.50      0.01     2.8      122    123    I   124      0.0  0.40    125  126    0    0    0
 125    2750.   3000.   13907.  0.035  16.36      0.08     4.6      120    124    I   125      0.0  0.40    126  127    0    0    0
 126    3600.   1200.    5197.  0.035  15.00      0.04     4.3      124    125    I   126      0.0  0.39    127    0    0    0    0
 127    2600.    400.     896.  0.035  17.31      0.01     2.2      125    126    I   127      0.0  0.39    128  129  130    0    0
 128    5500.   4500.   27836.  0.035   8.49    237.15     6.2       87    127    I   128      0.0  0.40    129    0    0    0    0
 129    9000.    750.    2241.  0.035   5.00      0.10     3.0      127    128    I   129      0.0  0.40     13  131  132    0    0
 130   12500.   2700.    8344.  0.035   3.60   -236.97     3.1       36    127    I   130      0.0  0.40    131  133  134    0    0
 131    2490.   1800.   25734.  0.017  19.07   1106.75    14.3      129    130    I   131   -450.0  0.40    132  133  135    0    0
 132    2610.    900.    8364.  0.020  17.24    413.13     9.3      129    131    I   132      0.0  0.40    135  136  137  138    0
 133    1600.   1650.   12039.  0.020  25.00    -49.31     7.3      130    131    I   133      0.0  0.40    137    0    0    0    0
 134    2490.   2000.   32594.  0.017   0.0   -1156.07    16.3       14    130    I
 135    2560.   1350.    7149.  0.020   0.0     813.80     5.3      131    132    I
 136    2250.   2700.   11604.  0.020   0.0     -16.83     4.3       14    132    I
 137    2700.   1500.    6444.  0.022   0.0       0.01     4.3      132    133    I
 138    3750.   1800.   13160.  0.020   0.0    -796.86     7.3       79    132    I
 139    4140.   2250.   16508.  0.020   0.0     586.23     7.3       79     80    I


                   ***************   DIFFUSION CONSTANTS   ***************

                      CHANNEL    CHANNEL           CONSTANT (C4)
                   ----------------------------------------------------

                         1         133              25.00
```

```
**********************************     SUMMARY OF DISSOLVED OXYGEN (CONSTITUENT 6)  RATES     **********************************

                           PHOTOSYNTHESIS     RESPIRATION    PHOTIC DEPTH    BENTHIC DEMAND
        FROM       TO          (PHOT)            (PES)          (DEPTH)          (BENT)
        JUNC       JUNC          (MG/HR/UG CHLORO)              (FEET)
      --------------------------------------------------------------------------------------

           1          1       0.01200           0.0008           2.00           1.000
           2          4       0.01200           0.0008           3.50           1.000
           5         17       0.01200           0.0008           2.00           2.000
          18         27       0.01200           0.0008           2.00           1.500
          28        113       0.01200           0.0008           2.00           1.000
         114        114       0.01200           0.0008           3.50           1.000
         115        128       0.01200           0.0008           2.00           1.000
         129        130       0.01200           0.0008           2.00           2.000
         131        133       0.01200           0.0008           2.00           1.000



**********************************     SUMMARY OF NUTRIENT UPTAKE AND REGENERATION RATES     **********************************

     FROM      TO     CONST 1 UPTAKE    CONST 3 UPTAKE    CONST 1 REGEN    CONST 3 REGEN    CONST 5 REGEN
     JUNC     JUNC       (AMUPP)           (PHUPP)          (REGENN)         (REGEPP)         (REBOD)
    -----------------------------------------------------------------------------------------------------

       1       133        0.0               0.010            0.0              0.0              0.0
```

```
**************************************     SUMMARY OF CONSTITUENT DECAY RATES     **************************************

                       CONST 1       CONST 2       CONST 3 *     CONST 4       CONST 5       CONST 6
   FROM       TO     (DECAYK 1)    (DECAYK 2)    (DECAYK 3)    (DECAYK 4)    (DECAYK 5)    (DECAYK6)
   JUNC      JUNC    (PER DAY)     (PER DAY)     (PER DAY)     (PER DAY)     (PER DAY)     (PER DAY)
---------------------------------------------------------------------------------------------------------

      1         1      0.150         0.090         0.030         0.020         0.170         0.0

      2         8      0.050         0.090         0.030         0.020         0.100         0.0

      5       113      0.150         0.090         0.030         0.020         0.170         0.0

    114       114      0.050         0.090         0.030         0.020         0.100         0.0

    115       133      0.150         0.090         0.030         0.020         0.170         0.0


*  CONSTITUENT 3 UNDERGOES 2ND ORDER DECAY




         *****************************     SUMMARY OF CONSTANT WASTEWATER  LOADS     *****************************

                         CONSTITUENT 1      CONSTITUENT 2      CONSTITUENT 3      CONSTITUENT 4      CONSTITUENT 5      CONSTITUENT 6
 JUNC.    TOTAL FLOW    CONC.    LOAD     CONC.    LOAD      CONC.    LOAD     CONC.    LOAD      CONC.    LOAD      CONC.    LOAD
            (CFS)      (MG/L) (LB/DAY)   (MG/L) (LB/DAY)   (MG/L) (LB/DAY)   (UG/L) (LB/DAY)   (MG/L) (LB/DAY)   (MG/L) (LB/DAY)
-------------------------------------------------------------------------------------------------------------------------------------

 131       -450.0      20.0   48546.      0.0        0.    25.0   60683.      0.0        0.    35.0   84956.      2.0    4855.
```

```
****************************    SUMMARY OF BANK LOADS    ****************************

       SHORE  BANK     CYCLES    CONSTITUENT 1     CONSTITUENT 2     CONSTITUENT 3     CONSTITUENT 4     CONSTITUENT 5     CONSTITUENT 6
JUNC.  LINE   FLOW   START STOP   CONC.   LOAD      CONC.   LOAD      CONC.   LOAD      CONC.   LOAD      CONC.   LOAD      CONC.   LOAD
       (MI)   (CFS)              (MG/L) (LB/DAY)   (MG/L) (LB/DAY)   (MG/L) (LB/DAY)   (UG/L) (LB/DAY)   (MG/L) (LB/DAY)   (MG/L) (LB/DAY)
---------------------------------------------------------------------------------------------------------------------------------------

 10    0.6    -80.   100  105    10.0    4315.      5.0    2156.     15.0    6473.      0.0      0.      30.0   12946.      0.0      0.
 11    0.9    -90.   100  106    10.0    4855.      5.0    2427.     15.0    7282.      0.0      0.      30.0   14564.      0.0      0.
 12    1.2   -120.   100  106    10.0    6473.      5.0    3236.     15.0    9709.      0.0      0.      30.0   19418.      0.0      0.
 13    0.9    -90.   100  106    10.0    4855.      5.0    2427.     15.0    7282.      0.0      0.      30.0   14564.      0.0      0.
 14    0.6    -60.   100  106    10.0    3236.      5.0    1618.     15.0    4855.      0.0      0.      30.0    9709.      0.0      0.
 15    0.5    -50.   100  106    10.0    2697.      5.0    1349.     15.0    4046.      0.0      0.      30.0    8091.      0.0      0.
 16    0.0      0.   100  106    10.0       0.      5.0       0.     15.0       0.      0.0      0.      30.0       0.      0.0      0.
 17    0.6    -60.   100  106    10.0    3236.      5.0    1618.     15.0    4855.      0.0      0.      30.0    9709.      0.0      0.
 18    1.6   -160.   100  106    10.0    8630.      5.0    4315.     15.0   12946.      0.0      0.      30.0   25891.      0.0      0.
 19    0.9    -90.   100  106    10.0    4855.      5.0    2427.     15.0    7282.      0.0      0.      30.0   14564.      0.0      0.
 20    1.6   -160.   100  106    10.0    6630.      5.0    4315.     15.0   12946.      0.0      0.      30.0   25891.      0.0      0.



****************************    SUMMARY OF UPPER BOUNDARY CONDITIONS  (NODE 114)    ****************************

INCREMENT               CONSTITUENT 1      CONSTITUENT 2      CONSTITUENT 3      CONSTITUENT 4      CONSTITUENT 5      CONSTITUENT 6
NO.  LENGTH    FLOW     CONC.    LOAD      CONC.   LOAD       CONC.   LOAD       CONC.   LOAD       CONC.   LOAD       CONC.   LOAD
    (CYCLES)   (CFS)    (MG/L) (LB/DAY)   (MG/L) (LB/DAY)    (MG/L) (LB/DAY)    (UG/L) (LB/DAY)    (MG/L) (LB/DAY)    (MG/L) (LB/DAY)
---------------------------------------------------------------------------------------------------------------------------------------

 1    2.00   -1500.    0.10      809.     0.30    2427.      0.20    1618.     25.00  202275.      4.00   32364.      6.00   48546.
 2    6.00   -1500.    0.05      405.     0.20    1618.      0.10     809.     20.00  161820.      3.00   24273.      7.10   57446.
```

```
*********************************   SUMMARY OF INITIAL CONCENTRATIONS   *********************************

      FROM      TO     CONST 1    CONST 2    CONST 3    CONST 4    CONST 5    CONST 6
      JUNC     JUNC    (MG/L)     (MG/L)     (MG/L)     (UG/L)     (MG/L)     (MG/L)
  ---------------------------------------------------------------------------------------
        1        1      0.01       0.10       0.10      10.00       1.00       8.00
        2        5      0.05       0.20       0.10      30.00       1.50       6.80
        6        9      0.40       0.25       0.70      30.00       1.70       6.80
       10       15      1.35       0.50       2.50      35.00       5.00       1.00
       16       20      1.30       1.60       1.60      70.00       7.00       2.50
       21       25      0.70       1.50       1.20      85.00       6.50       3.50
       26       30      0.10       1.00       0.70      70.00       5.00       5.50
       31       35      0.04       0.80       0.40      65.00       3.00       6.80
       36       40      0.02       0.60       0.40      65.00       1.50       6.80
       41       45      0.01       0.30       0.60      30.00       1.00       8.00
       46       65      0.01       0.10       0.60      10.00       1.00       9.00
       66       77      1.40       0.45       2.10      30.00       2.50       2.80
       78       82      1.50       1.00       2.50      65.00       5.00       1.00
       83       85      0.40       1.40       2.00      75.00       6.00       5.00
       86      128      0.30       0.20       1.00      30.00       1.50       6.00
      129      130      1.90       0.35       2.80      30.00       4.50       0.50
      131      133      1.50       1.00       2.50      65.00       5.00       1.00
```

```
*********************************   TIDAL CYCLE VARIATION OF SEAWARD BOUNDARY CONDITIONS   ******************************

                                      SPECIFIED CONCENTRATIONS AT JUNCTION 1

       INTERVAL    CONSTITUENT 1    CONSTITUENT 2    CONSTITUENT 3    CONSTITUENT 4    CONSTITUENT 5    CONSTITUENT 6
                      (MG/L)           (MG/L)           (MG/L)           (UG/L)           (MG/L)           (MG/L)
------------------------------------------------------------------------------------------------------------------------

           1           0.05             0.10             0.20            10.00             1.00             8.00
           2           0.05             0.10             0.20            10.00             1.00             8.00
           3           0.05             0.10             0.20            10.00             1.00             8.00
           4           0.05             0.10             0.20            10.00             1.00             8.00
           5           0.05             0.10             0.20            10.00             1.00             8.00
           6           0.05             0.10             0.20            10.00             1.00             8.00
           7           0.05             0.10             0.20            10.00             1.00             8.00
           8           0.05             0.10             0.20            10.00             1.00             8.00
           9           0.05             0.10             0.20            10.00             1.00             8.00
          10           0.05             0.10             0.20            10.00             1.00             8.00
          11           0.05             0.10             0.20            10.00             1.00             8.00
          12           0.05             0.10             0.20            10.00             1.00             8.00
          13           0.05             0.10             0.20            10.00             1.00             8.00
          14           0.05             0.10             0.20            10.00             1.00             8.00
          15           0.05             0.10             0.20            10.00             1.00             8.00
          16           0.05             0.10             0.20            10.00             1.00             8.00
          17           0.05             0.10             0.20            10.00             1.00             8.00
          18           0.05             0.10             0.20            10.00             1.00             8.00
          19           0.05             0.10             0.20            10.00             1.00             8.00
          20           0.05             0.10             0.20            10.00             1.00             8.00
          21           0.05             0.10             0.20            10.00             1.00             8.00
          22           0.05             0.10             0.20            10.00             1.00             8.00
          23           0.05             0.10             0.20            10.00             1.00             8.00
          24           0.05             0.10             0.20            10.00             1.00             8.00
          25           0.05             0.10             0.20            10.00             1.00             8.00
```

```
                                        HIGH SLACK PREDICTIONS

JUNCTION   HEAD      CONSTITUENT 1    CONSTITUENT 2    CONSTITUENT 3    CONSTITUENT 4    CONSTITUENT 5    CONSTITUENT 6
           (FT)         (MG/L)           (MG/L)           (MG/L)           (UG/L)           (MG/L)           (MG/L)
------------------------------------------------------------------------------------------------------------------------

                                 CYCLE  480        10 DAYS,  6.00 HOURS

    1      0.28         0.05             0.10             0.20            10.00             1.01             8.00
   65      0.22         0.04             0.09             0.24            11.51             0.66             7.13
------------------------------------------------------------------------------------------------------------------------

                                 CYCLE  481        10 DAYS,  6.50 HOURS

   64      0.36         0.03             0.09             0.29            13.07             0.42             6.50
   63      0.33         0.02             0.08             0.34            14.32             0.27             6.23
   62      0.30         0.02             0.08             0.39            15.14             0.19             6.06
   61      0.26         0.01             0.07             0.42            15.67             0.14             5.95
------------------------------------------------------------------------------------------------------------------------

                                 CYCLE  482        10 DAYS,  7.00 HOURS

   60      0.44         0.01             0.07             0.45            15.86             0.11             5.87
   59      0.40         0.01             0.07             0.47            15.99             0.09             5.82
   58      0.37         0.01             0.07             0.49            16.15             0.08             5.81
------------------------------------------------------------------------------------------------------------------------

                                 CYCLE  483        10 DAYS,  7.50 HOURS

   57      0.55         0.01             0.06             0.50            16.16             0.08             5.83
------------------------------------------------------------------------------------------------------------------------

                                 CYCLE  484        10 DAYS,  8.00 HOURS

   56      0.73         0.01             0.06             0.50            16.06             0.07             5.83
   55      0.71         0.01             0.06             0.50            16.42             0.07             5.87
   54      0.69         0.01             0.06             0.50            17.12             0.07             5.89
------------------------------------------------------------------------------------------------------------------------

                                 CYCLE  485        10 DAYS,  8.50 HOURS

   53      0.82         0.01             0.07             0.50            18.00             0.07             5.91
   52      0.79         0.01             0.07             0.50            19.42             0.07             5.92
   51      0.77         0.01             0.08             0.49            21.30             0.07             5.95
   50      0.71         0.01             0.09             0.49            24.03             0.07             6.03
   49      0.66         0.01             0.10             0.48            26.37             0.07             6.10
------------------------------------------------------------------------------------------------------------------------

                                 CYCLE  486        10 DAYS,  9.00 HOURS

   48      0.69         0.01             0.12             0.46            29.51             0.07             6.15
   47      0.58         0.01             0.14             0.47            32.10             0.07             6.13
   46      0.65         0.01             0.15             0.46            34.37             0.08             6.09
   45      0.72         0.01             0.19             0.45            36.69             0.09             6.15
   44      0.73         0.01             0.22             0.45            40.99             0.09             6.23
------------------------------------------------------------------------------------------------------------------------
```

```
   43     0.28      0.01       0.26       0.44      44.68      0.09       6.34
   42     0.20      0.01       0.30       0.44      47.34      0.10       6.32
   41     0.13      0.01       0.36       0.44      49.63      0.11       6.20
   40     0.06      0.01       0.39       0.44      52.47      0.12       6.09
   39    -0.03      0.02       0.44       0.45      55.26      0.13       6.01
   38    -0.12      0.02       0.50       0.46      57.81      0.15       6.08
   37    -0.24      0.03       0.56       0.48      59.53      0.16       6.21
   36    -0.33      0.04       0.64       0.51      62.85      0.18       6.43
------------------------------------------------------------------------------

                    CYCLE  488        10 DAYS, 10.00 HOURS

   35    -0.16      0.05       0.73       0.55      65.92      0.21       6.35
   34    -0.22      0.07       0.84       0.59      69.13      0.24       5.88
   33    -0.25      0.08       0.90       0.62      71.16      0.25       5.62
   32    -0.29      0.10       0.99       0.67      73.71      0.28       5.57
   31    -0.34      0.12       1.09       0.73      76.28      0.30       5.40
   30    -0.41      0.15       1.17       0.79      78.29      0.32       5.29
   29    -0.47      0.20       1.28       0.84      80.66      0.35       5.21
------------------------------------------------------------------------------

                    CYCLE  489        10 DAYS, 10.50 HOURS

   28    -0.29      0.29       1.62       1.04      83.46      0.40       5.12
   27    -0.37      0.37       1.53       1.18      86.26      0.45       4.38
   26    -0.42      0.45       1.62       1.31      87.80      0.52       3.95
   25    -0.47      0.55       1.70       1.45      89.03      0.59       3.58
   24    -0.52      0.70       1.78       1.65      90.02      0.72       3.29
   23    -0.57      0.89       1.85       1.84      90.30      0.91       2.94
   22    -0.59      1.04       1.89       2.07      89.94      1.08       2.60
   21    -0.64      1.23       1.89       2.29      88.87      1.31       2.61
   20    -0.68      1.43       1.93       2.51      87.04      1.57       2.66
   19    -0.73      1.64       1.94       2.76      84.05      1.92       2.67
   18    -0.75      1.84       1.76       2.97      80.55      2.25       2.27
   17    -0.81      2.14       1.58       3.25      73.02      2.79       1.81
   16    -0.84      2.22       1.29       3.30      62.46      3.16       1.55
   15    -0.86      1.95       1.02       2.94      53.71      2.92       1.10
   14    -0.90      1.69       0.83       2.60      49.49      2.65       1.57
  130    -0.92      1.58       0.81       2.44      47.53      2.56       1.95
  129    -0.93      0.96       0.74       1.65      46.19      1.59       2.20
   13    -0.95      0.69       0.62       1.26      42.36      1.29       2.82
   12    -0.96      0.38       0.52       0.85      39.13      0.96       3.28
   11    -0.98      0.24       0.44       0.62      35.96      0.87       3.56
   10    -0.98      0.21       0.42       0.56      34.96      0.84       3.63
    9    -1.00      0.15       0.38       0.45      33.22      0.87       3.75
    8    -1.01      0.07       0.25       0.19      24.27      1.29       4.75
    7    -1.02      0.05       0.23       0.16      21.96      1.47       4.91
------------------------------------------------------------------------------

                    CYCLE  490        10 DAYS, 11.00 HOURS

    6    -0.96      0.05       0.21       0.11      20.76      1.62       4.97
    5    -0.94      0.05       0.20       0.10      20.21      1.81       5.32
    4    -0.95      0.05       0.20       0.10      20.01      1.95       5.49
    3    -0.95      0.05       0.20       0.10      19.90      2.16       5.94
    2    -0.96      0.05       0.21       0.10      19.85      2.63       5.69
  114    -0.97      1.05       0.20       0.10      20.02      3.03       7.21
```

LOW SLACK PREDICTIONS

JUNCTION	HEAD (FT)	CONSTITUENT 1 (MG/L)	CONSTITUENT 2 (MG/L)	CONSTITUENT 3 (MG/L)	CONSTITUENT 4 (UG/L)	CONSTITUENT 5 (MG/L)	CONSTITUENT 6 (MG/L)
		CYCLE 492		10 DAYS, 12.00 HOURS			
1	0.55	0.05	0.10	0.20	10.00	1.01	8.07
65	0.60	0.04	0.10	0.21	10.56	0.87	7.65
64	0.62	0.04	0.09	0.25	11.92	0.60	7.05
63	0.65	0.03	0.09	0.28	12.97	0.44	6.68
62	0.68	0.03	0.08	0.33	14.03	0.31	6.36
61	0.71	0.03	0.08	0.37	14.86	0.23	6.17
60	0.73	0.03	0.07	0.41	15.53	0.15	6.07
		CYCLE 493		10 DAYS, 12.50 HOURS			
59	0.62	0.01	0.07	0.44	15.63	0.11	5.91
58	0.65	0.01	0.07	0.47	15.09	0.09	5.86
		CYCLE 494		10 DAYS, 13.00 HOURS			
57	0.50	0.01	0.05	0.49	14.25	0.08	5.87
		CYCLE 495		10 DAYS, 13.50 HOURS			
56	0.74	0.01	0.06	0.49	16.13	0.07	5.86
55	0.77	0.01	0.06	0.50	16.24	0.07	5.90
54	0.40	0.01	0.06	0.50	16.47	0.07	5.91
		CYCLE 496		10 DAYS, 14.00 HOURS			
53	0.25	0.01	0.06	0.50	17.08	0.07	5.96
52	0.28	0.01	0.07	0.50	18.07	0.06	5.97
51	0.31	0.01	0.07	0.50	19.32	0.06	5.96
50	0.36	0.01	0.07	0.49	20.28	0.07	5.97
		CYCLE 497		10 DAYS, 14.50 HOURS			
49	0.27	0.01	0.08	0.49	22.64	0.07	6.06
48	0.36	0.01	0.09	0.49	24.75	0.07	5.18
47	0.35	0.01	0.10	0.46	27.06	0.07	6.27
		CYCLE 498		10 DAYS, 15.00 HOURS			
46	0.75	0.01	0.13	0.47	31.24	0.07	6.22
45	0.55	0.01	0.14	0.46	33.43	0.07	5.20
44	0.44	0.01	0.17	0.45	37.03	0.07	5.27
43	0.72	0.01	0.19	0.45	39.42	0.09	6.38
42	1.30	0.01	[illegible]	[illegible]	[illegible]	0.08	[illegible]

```
                            CYCLE  499          10 DAYS, 15.50 HOURS

   41     0.75        0.01         0.28         0.44         45.68         0.09         6.55
   40     0.82        0.01         0.32         0.44         48.76         0.10         6.47
   39     0.90        0.01         0.37         0.44         51.46         0.11         6.33
   38     0.97        0.02         0.40         0.44         53.25         0.11         6.28
   37     1.07        0.02         0.45         0.45         55.62         0.13         6.30
   36     1.14        0.02         0.50         0.46         57.89         0.14         6.41
-------------------------------------------------------------------------------------------------

                            CYCLE  500          10 DAYS, 16.00 HOURS

   35     1.08        0.03         0.55         0.48         59.67         0.15         6.59
   34     1.12        0.03         0.60         0.49         61.59         0.16         6.81
   33     1.15        0.04         0.66         0.52         63.65         0.18         6.67
   32     1.19        0.04         0.76         0.56         67.08         0.20         6.41
   31     1.21        0.07         0.86         0.60         69.89         0.23         6.17
   30     1.26        0.09         0.96         0.65         72.56         0.25         5.93
   29     1.30        0.12         1.07         0.72         75.96         0.28         5.74
-------------------------------------------------------------------------------------------------

                            CYCLE  501          10 DAYS, 16.50 HOURS

   28     1.19        0.14         1.14         0.77         77.93         0.29         5.88
   27     1.25        0.17         1.21         0.83         79.63         0.31         5.75
   26     1.28        0.21         1.30         0.91         81.61         0.34         5.58
   25     1.31        0.28         1.42         1.03         84.20         0.39         5.29
   24     1.34        0.37         1.54         1.19         86.76         0.44         4.80
   23     1.37        0.46         1.62         1.30         88.24         0.49         4.43
   22     1.39        0.53         1.67         1.39         89.15         0.53         4.06
   21     1.41        0.61         1.75         1.53         90.20         0.62         3.72
   20     1.43        0.73         1.81         1.59         90.83         0.73         3.65
   19     1.46        0.93         1.87         1.90         91.10         0.93         3.35
   18     1.48        1.10         1.91         2.14         90.51         1.12         3.22
   17     1.51        1.37         1.89         2.44         88.02         1.48         3.09
-------------------------------------------------------------------------------------------------

                            CYCLE  502          10 DAYS, 17.00 HOURS

   16     1.31        1.69         1.86         2.79         86.33         1.95         3.28
   15     1.33        1.73         1.93         2.89         83.51         2.10         2.82
   14     1.35        1.87         1.78         2.96         81.23         2.26         2.48
  130     1.36        2.13         1.58         3.25         73.08         2.79         1.92
  129     1.37        2.24         1.36         3.34         64.28         3.15         1.59
   13     1.38        2.21         1.10         3.26         55.85         3.30         1.56
   12     1.39        1.78         0.89         2.70         49.73         2.79         1.97
   11     1.40        1.15         0.72         1.89         45.26         1.94         2.61
   10     1.41        0.74         0.62         1.33         42.13         1.39         3.09
    9     1.42        0.33         0.48         0.75         37.43         0.93         3.67
    8     1.43        0.14         0.33         0.37         29.71         1.04         4.44
    7     1.44        0.07         0.25         0.20         24.19         1.29         4.80
-------------------------------------------------------------------------------------------------

                            CYCLE  503          10 DAYS, 17.50 HOURS

    6     1.17        0.05         0.22         0.12         21.21         1.52         4.98
    5     1.17        0.05         0.21         0.11         20.31         1.72         5.27
    4     1.17        0.04         0.20         0.10         19.99         1.91         5.72
    3     1.17        0.05         0.20         0.10         19.65         2.17         5.70
```

```
 ***************************************************          WATER QUALITY SUMMARY      *****************************************************
     STARTS AT CYCLE  500 ( 10 DAYS 10.0 HOURS)                                          ENDS AT CYCLE 1000 ( 20 DAYS 20.0 HOURS)


 JUNC.   CONSTITUENT 1         CONSTITUENT 2          CONSTITUENT 3         CONSTITUENT 4          CONSTITUENT 5          CONSTITUENT 6
         MIN   MAX   AVG       MIN   MAX   AVG        MIN   MAX   AVG       MIN    MAX    AVG      MIN   MAX   AVG        MIN   MAX   AVG
 ---------------------------------------------------------------------------------------------------------------------------------------

   1    0.05  0.05  0.05      0.10  0.10  0.10       0.20  0.20  0.20      10.0   10.0   10.0     1.00  1.00  1.00       8.00  8.00  8.00
   2    0.05  0.05  0.05      0.20  0.20  0.20       0.10  0.10  0.10      19.9   19.9   19.9     2.62  2.64  2.63       6.57  6.78  6.58
   3    0.04  0.05  0.04      0.20  0.20  0.20       0.10  0.10  0.10      19.7   19.9   19.8     2.11  2.16  2.13       5.86  6.09  5.97
   4    0.04  0.04  0.04      0.20  0.21  0.20       0.10  0.10  0.10      19.7   20.0   19.7     1.87  1.95  1.91       5.56  5.87  5.72
   5    0.04  0.05  0.04      0.20  0.21  0.20       0.10  0.11  0.10      19.6   20.4   19.7     1.66  1.81  1.72       5.11  5.55  5.35
   6    0.04  0.05  0.04      0.20  0.22  0.20       0.09  0.13  0.10      19.5   21.5   19.9     1.44  1.61  1.51       4.79  5.26  5.08
   7    0.04  0.05  0.05      0.20  0.26  0.22       0.11  0.21  0.14      20.0   24.7   21.5     1.17  1.45  1.30       4.53  5.16  4.94
   8    0.05  0.15  0.09      0.21  0.35  0.27       0.14  0.41  0.24      21.3   30.0   25.2     0.92  1.27  1.06       4.04  5.19  4.49
   9    0.11  0.30  0.21      0.30  0.51  0.39       0.32  0.85  0.53      29.7   38.4   32.7     0.75  0.98  0.82       3.22  4.35  3.90
  10    0.15  0.77  0.45      0.34  0.67  0.46       0.42  1.59  0.88      30.2   43.0   36.0     0.76  1.64  1.06       2.50  4.25  3.54
  11    0.19  1.49  0.70      0.36  0.79  0.55       0.48  2.31  1.23      31.0   46.0   38.4     0.77  2.61  1.38       1.94  4.19  3.23
  12    0.33  2.07  1.13      0.43  0.96  0.68       0.71  3.07  1.81      33.9   51.3   42.4     0.67  3.22  1.93       1.31  3.92  2.71
  13    0.62  2.33  1.56      0.53  1.20  0.85       1.12  3.48  2.41      37.2   59.0   47.6     1.20  3.59  2.45       0.80  3.47  2.19
  14    1.64  2.77  1.96      0.81  1.92  1.39       2.48  3.44  3.00      45.1   67.7   66.9     2.10  3.41  2.68       0.79  3.23  1.97
  15    1.65  2.15  1.91      0.96  1.95  1.55       2.75  3.29  2.96      50.0   89.7   73.2     1.85  3.14  2.49       0.97  3.35  2.06
  16    1.39  2.27  1.88      1.27  2.05  1.74       2.48  3.39  2.98      61.1   95.6   80.6     1.43  3.18  2.32       1.42  3.64  2.62
  17    1.32  2.14  1.72      1.59  2.05  1.86       2.41  3.26  2.82      73.4   96.7   86.0     1.34  2.87  2.01       1.77  3.71  2.94
  18    1.03  1.56  1.43      1.77  2.12  1.97       2.09  2.97  2.52      81.1  102.1   92.0     0.92  2.25  1.53       2.25  3.92  3.14
  19    0.82  1.47  1.23      1.85  2.12  2.00       1.83  2.77  2.30      86.7  104.0   94.9     0.67  1.93  1.24       2.56  4.19  3.36
  20    0.66  1.44  1.04      1.80  2.11  2.00       1.66  2.52  2.08      87.8  104.6   96.9     0.52  1.57  0.96       2.69  4.21  3.45
  21    0.58  1.25  0.67      1.73  2.11  1.98       1.49  2.32  1.89      89.8  104.5   97.9     0.39  1.31  0.79       2.75  4.54  3.63
  22    0.46  1.06  0.72      1.66  2.11  1.93       1.35  2.10  1.71      88.9  104.5   98.1     0.30  1.07  0.62       2.80  4.91  3.86
  23    0.41  0.91  0.63      1.60  2.11  1.89       1.27  1.94  1.59      87.9  104.5   97.8     0.26  0.91  0.52       3.17  5.21  4.20
  24    0.35  0.71  0.51      1.53  2.05  1.81       1.17  1.70  1.43      86.5  104.4   96.8     0.21  0.70  0.40       3.45  5.57  4.55
  25    0.24  0.56  0.39      1.39  1.97  1.68       1.00  1.51  1.25      83.7  103.9   94.5     0.13  0.57  0.30       3.83  6.10  4.99
  26    0.15  0.46  0.31      1.27  1.88  1.56       0.88  1.37  1.12      81.1  102.6   91.8     0.09  0.49  0.24       4.10  6.41  5.36
  27    0.14  0.38  0.25      1.19  1.79  1.45       0.81  1.25  1.01      79.2  100.6   89.3     0.07  0.43  0.20       4.40  6.56  5.66
  28    0.12  0.30  0.19      1.12  1.55  1.34       0.70  1.11  0.91      77.6   97.8   86.5     0.06  0.39  0.16       5.22  6.97  6.06
  29    0.10  0.21  0.14      1.07  1.43  1.22       0.72  0.93  0.81      76.0   92.2   83.2     0.05  0.32  0.13       5.25  6.98  6.11
  30    0.07  0.15  0.11      0.95  1.30  1.10       0.65  0.82  0.73      73.0   89.1   79.8     0.03  0.29  0.11       5.36  6.87  6.15
  31    0.05  0.12  0.08      0.85  1.18  1.00       0.59  0.75  0.67      69.9   85.1   76.7     0.03  0.27  0.10       5.48  6.85  6.25
  32    0.04  0.10  0.07      0.76  1.06  0.89       0.54  0.68  0.61      67.1   81.3   73.4     0.02  0.24  0.09       5.63  6.96  6.40
  33    0.03  0.08  0.05      0.64  0.95  0.79       0.49  0.63  0.56      63.7   77.7   70.0     0.02  0.22  0.08       5.77  7.23  6.58
  34    0.02  0.07  0.04      0.56  0.87  0.70       0.46  0.60  0.53      61.5   75.0   67.2     0.01  0.21  0.07       5.94  7.39  6.74
  35    0.02  0.05  0.03      0.50  0.75  0.62       0.44  0.55  0.49      59.5   71.0   64.3     0.01  0.19  0.06       6.19  7.55  6.86
  36    0.01  0.04  0.02      0.45  0.66  0.54       0.42  0.51  0.46      57.9   66.5   61.5     0.01  0.16  0.05       6.11  7.67  6.80
  37    0.01  0.03  0.02      0.39  0.55  0.47       0.41  0.48  0.44      55.6   62.6   58.7     0.01  0.16  0.05       5.99  7.36  6.55
  38    0.01  0.02  0.01      0.33  0.50  0.41       0.39  0.46  0.43      53.2   60.0   56.3     0.01  0.13  0.04       5.93  7.00  6.42
  39    0.01  0.02  0.01      0.29  0.44  0.36       0.39  0.45  0.42      51.5   57.0   54.0     0.01  0.12  0.04       5.94  6.75  6.36
  40    0.01  0.01  0.01      0.25  0.36  0.31       0.38  0.44  0.41      49.0   54.0   51.4     0.01  0.11  0.04       6.06  6.74  6.42
  41    0.00  0.01  0.01      0.20  0.34  0.27       0.38  0.44  0.41      45.9   51.4   48.8     0.01  0.10  0.03       6.13  6.80  6.49
  42    0.00  0.01  0.01      0.16  0.30  0.22       0.37  0.44  0.40      42.5   49.3   46.1     0.01  0.09  0.03       6.19  6.96  6.52
  43    0.00  0.01  0.01      0.13  0.26  0.19       0.37  0.45  0.41      39.7   47.2   43.5     0.01  0.08  0.03       6.16  6.92  6.46
  44    0.00  0.01  0.00      0.12  0.21  0.16       0.38  0.45  0.41      37.3   43.7   40.8     0.01  0.08  0.03       6.07  6.68  6.32
  45    0.00  0.01  0.00      0.09  0.19  0.13       0.38  0.45  0.41      33.5   41.9   38.0     0.00  0.07  0.03       6.00  6.52  6.21
  46    0.00  0.01  0.00      0.08  0.15  0.11       0.38  0.47  0.42      31.5   39.1   35.2     0.00  0.07  0.02       6.03  6.13  6.10
```

49	0.00	0.01	0.00	0.05	0.10	0.07	0.39	0.49	0.44	27.0	31.1	27.3	0.00	0.04	0.02	5.87	5.24	6.05
50	0.00	0.01	0.00	0.05	0.09	0.07	0.40	0.49	0.44	20.7	29.0	25.0	0.00	0.04	0.02	5.77	5.16	5.93
51	0.00	0.01	0.00	0.04	0.08	0.06	0.40	0.49	0.44	19.6	25.2	23.1	0.00	0.05	0.02	5.74	6.13	5.86
52	0.00	0.01	0.00	0.04	0.07	0.05	0.40	0.50	0.45	18.4	24.2	21.5	0.01	0.05	0.02	5.71	6.03	5.85
53	0.00	0.01	0.00	0.04	0.07	0.05	0.40	0.50	0.45	17.4	22.5	20.0	0.01	0.06	0.02	5.70	6.01	5.92
54	0.00	0.01	0.00	0.04	0.06	0.05	0.40	0.50	0.45	16.7	21.1	18.9	0.01	0.06	0.02	5.69	5.96	5.90
55	0.00	0.01	0.00	0.04	0.06	0.05	0.39	0.50	0.44	16.3	19.7	18.1	0.01	0.07	0.03	5.65	5.96	5.76
56	0.00	0.01	0.00	0.04	0.06	0.05	0.39	0.49	0.44	16.2	19.5	17.4	0.01	0.07	0.03	5.62	5.92	5.74
57	0.00	0.01	0.01	0.04	0.05	0.05	0.38	0.49	0.43	15.3	17.6	17.1	0.02	0.07	0.03	5.63	5.55	5.76
58	0.00	0.01	0.01	0.04	0.06	0.05	0.36	0.46	0.42	16.2	17.2	16.8	0.02	0.08	0.04	5.66	5.91	5.75
59	0.01	0.01	0.01	0.04	0.07	0.05	0.34	0.46	0.39	15.9	16.7	16.4	0.04	0.11	0.07	5.67	5.90	5.75
60	0.01	0.01	0.01	0.04	0.07	0.06	0.31	0.44	0.37	15.6	16.4	16.0	0.04	0.15	0.10	5.75	6.02	5.93
61	0.01	0.02	0.01	0.05	0.08	0.06	0.29	0.42	0.34	14.8	16.0	15.4	0.09	0.21	0.15	5.66	6.16	6.02
62	0.01	0.02	0.02	0.06	0.08	0.07	0.26	0.38	0.31	13.9	15.4	14.7	0.15	0.31	0.22	5.98	6.35	6.17
63	0.02	0.03	0.02	0.06	0.09	0.08	0.24	0.34	0.26	12.9	14.6	13.7	0.23	0.44	0.33	6.15	6.68	6.43
64	0.03	0.06	0.03	0.08	0.10	0.08	0.22	0.29	0.24	11.8	13.3	12.5	0.38	0.60	0.50	6.52	7.07	6.91
65	0.04	0.06	0.04	0.09	0.10	0.09	0.20	0.24	0.22	10.6	11.7	11.0	0.67	0.85	0.75	7.10	7.67	7.62
66	0.11	0.22	0.15	0.34	0.48	0.40	0.40	0.64	0.51	32.0	41.1	36.0	0.43	0.75	0.58	2.47	3.63	3.28
67	0.09	0.18	0.12	0.36	0.52	0.43	0.42	0.69	0.52	34.5	43.9	39.0	0.33	0.59	0.44	2.18	3.49	2.95
68	0.07	0.18	0.11	0.37	0.56	0.45	0.43	0.73	0.55	37.4	46.7	42.2	0.24	0.45	0.32	1.97	3.25	2.72
69	0.07	0.18	0.11	0.39	0.59	0.46	0.45	0.77	0.56	40.7	48.8	45.1	0.18	0.34	0.24	1.85	3.42	2.69
70	0.06	0.18	0.10	0.40	0.61	0.50	0.46	0.81	0.61	42.9	50.9	47.5	0.17	0.27	0.19	1.92	3.97	2.97
71	0.05	0.18	0.10	0.41	0.53	0.51	0.48	0.85	0.63	45.1	52.4	49.5	0.09	0.23	0.15	2.25	4.64	3.59
72	0.04	0.19	0.09	0.42	0.67	0.52	0.49	0.98	0.66	47.0	53.6	51.3	0.06	0.20	0.11	2.98	4.18	4.53
73	0.04	0.19	0.09	0.42	0.64	0.53	0.50	0.89	0.67	48.1	54.1	52.3	0.04	0.18	0.09	3.52	7.12	5.49
74	0.04	0.19	0.09	0.39	0.63	0.51	0.50	0.90	0.67	48.6	53.5	51.8	0.03	0.15	0.07	4.71	7.29	6.21
75	0.03	0.19	0.08	0.38	0.61	0.49	0.49	0.88	0.66	47.3	52.9	50.7	0.02	0.13	0.06	5.50	7.33	6.56
76	0.03	0.17	0.06	0.34	0.58	0.45	0.46	0.86	0.63	43.8	51.1	48.1	0.02	0.12	0.05	5.87	7.45	6.75
77	0.03	0.15	0.07	0.30	0.51	0.40	0.42	0.80	0.56	39.7	46.9	43.9	0.01	0.10	0.04	5.79	7.09	6.57
78	0.59	0.72	0.65	0.78	0.93	0.85	1.29	1.52	1.40	50.5	58.3	54.4	0.81	1.00	0.89	1.00	2.20	1.49
79	2.55	3.39	3.01	1.53	1.73	1.64	3.72	4.70	4.24	68.2	77.8	73.4	3.37	4.89	4.16	1.49	3.46	2.50
80	1.89	2.91	2.34	1.66	1.87	1.78	3.00	4.03	3.50	74.7	85.3	80.5	2.26	3.77	3.00	1.73	3.69	2.49
81	1.44	1.66	1.57	1.74	1.95	1.86	2.52	2.75	2.65	80.6	89.7	85.9	1.50	1.93	1.74	4.37	10.51	6.89
82	1.01	1.13	1.08	1.93	2.20	2.09	2.08	2.20	2.15	91.0	103.9	98.7	0.86	1.13	0.98	5.35	10.62	7.71
83	0.50	0.67	0.59	1.70	2.06	1.91	1.62	1.66	1.55	89.3	106.4	96.9	0.77	0.55	0.46	4.40	11.64	7.20
84	0.23	0.29	0.25	1.42	1.65	1.53	0.99	1.08	1.04	84.3	97.9	91.4	0.12	0.37	0.20	6.81	13.37	9.49
85	0.15	0.21	0.18	1.24	1.48	1.36	0.86	0.95	0.90	80.3	93.9	87.2	0.07	0.33	0.15	6.20	11.12	8.28
86	0.02	0.04	0.03	0.64	0.68	0.66	0.46	0.57	0.50	63.6	68.8	66.4	0.02	0.18	0.06	7.82	10.37	8.99
87	0.02	0.04	0.03	0.62	0.54	0.64	0.48	0.52	0.50	63.1	63.1	65.5	0.01	0.18	0.06	6.90	9.52	8.05
88	0.02	0.04	0.03	0.59	0.56	0.63	0.46	0.53	0.49	61.9	67.9	65.4	0.01	0.17	0.06	8.43	11.61	9.70
89	0.02	0.03	0.02	0.56	0.60	0.58	0.45	0.49	0.47	61.6	64.6	63.1	0.01	0.14	0.06	7.17	11.33	8.93
90	0.01	0.03	0.02	0.53	0.55	0.54	0.43	0.50	0.46	60.2	64.1	62.4	0.01	0.15	0.05	7.18	8.97	8.10
91	0.01	0.02	0.02	0.48	0.53	0.50	0.43	0.45	0.44	59.2	61.6	60.4	0.01	0.15	0.05	7.20	11.28	8.96
92	0.01	0.02	0.01	0.41	0.47	0.44	0.40	0.44	0.42	57.2	59.7	57.9	0.01	0.13	0.05	7.45	10.46	6.79
93	0.00	0.01	0.01	0.20	0.29	0.23	0.37	0.44	0.40	47.4	48.7	46.1	0.01	0.09	0.03	7.49	9.33	6.34
94	0.00	0.01	0.01	0.16	0.24	0.20	0.37	0.44	0.40	44.5	46.4	45.6	0.01	0.08	0.03	7.35	9.54	6.37
95	0.00	0.01	0.00	0.08	0.13	0.10	0.38	0.47	0.42	32.5	36.4	34.9	0.00	0.07	0.02	7.12	8.06	7.90
96	0.00	0.01	0.00	0.07	0.12	0.09	0.39	0.50	0.43	31.1	34.6	33.1	0.00	0.07	0.02	7.11	7.99	7.51
97	0.00	0.01	0.00	0.04	0.07	0.05	0.41	0.51	0.45	19.6	23.4	21.4	0.00	0.04	0.02	6.69	7.38	7.01
98	0.00	0.01	0.00	0.03	0.06	0.05	0.41	0.51	0.45	16.7	19.1	17.9	0.01	0.04	0.02	6.61	7.26	6.93
99	0.00	0.01	0.01	0.03	0.08	0.05	0.40	0.53	0.46	17.7	19.0	18.1	0.01	0.07	0.03	6.27	5.78	6.49
100	0.00	0.02	0.01	0.03	0.09	0.05	0.41	0.56	0.47	17.6	20.8	18.8	0.01	0.07	0.02	5.65	7.90	7.33
101	0.00	0.02	0.01	0.04	0.09	0.06	0.37	0.52	0.43	17.3	20.4	18.6	0.02	0.07	0.04	6.23	6.59	6.40
102	0.00	0.02	0.01	0.04	0.09	0.06	0.35	0.51	0.44	17.2	20.5	16.6	0.03	0.08	0.04	6.28	5.62	6.44
103	0.00	0.01	0.01	0.06	0.07	0.05	0.36	0.53	0.42	16.7	19.0	17.2	0.02	0.03	0.04	6.59	7.03	6.75
104	0.01	0.02	0.01	0.05	0.09	0.06	0.29	0.43	0.35	15.0	18.5	16.8	0.02	0.13	0.09	6.39	5.80	6.57
105	0.02	0.13	0.04	0.25	0.43	0.34	0.35	0.71	0.51	33.5	41.1	37.0	0.01	0.09	0.03	5.62	6.77	6.78
106	0.02	0.11	0.05	0.19	0.34	0.27	0.28	0.61	0.42	25.4	35.3	31.0	0.01	0.09	0.02	5.35	5.41	5.92
107	0.01	0.08	0.03	0.13	0.25	0.14	0.20	[illegible]	0.30	19.4	25.7	22.4	0.00	[illegible]	0.02	4.94	[illegible]	5.46

110	0.05	0.13	0.08	0.35	0.41	0.38	0.45	0.70	0.56	43.1	46.2	45.2	0.13	0.22	0.16	0.31	0.66	0.57
111	0.04	0.13	0.06	0.32	0.35	0.34	0.48	0.72	0.59	46.3	49.3	48.5	0.06	0.14	0.08	0.00	0.16	0.05
112	0.04	0.10	0.05	0.43	0.45	0.54	0.53	0.92	0.70	51.7	55.9	54.6	0.04	0.14	0.07	5.45	7.35	6.53
113	0.04	0.19	0.09	0.43	0.64	0.54	0.54	0.98	0.71	53.0	56.6	55.4	0.02	0.13	0.05	6.65	8.92	7.86
114	0.05	0.05	0.05	0.20	0.20	0.20	0.10	0.10	0.10	20.0	20.0	23.0	3.02	3.03	3.02	7.06	7.22	7.14
115	0.47	0.57	0.52	1.66	2.05	1.90	1.38	1.54	1.43	89.2	106.8	99.0	0.30	0.50	0.60	6.56	12.14	9.15
116	0.39	0.67	0.43	1.57	2.03	1.84	1.25	1.43	1.36	85.5	107.1	98.3	0.21	0.47	0.31	8.43	14.14	11.00
117	0.33	0.30	0.36	1.50	2.00	1.79	1.17	1.33	1.27	83.9	107.2	97.2	0.17	0.42	0.25	9.35	15.44	12.76
118	0.30	0.33	0.32	1.44	1.96	1.74	1.12	1.25	1.20	82.0	105.6	95.8	0.14	0.37	0.22	8.90	15.04	11.16
119	0.12	0.18	0.16	1.17	1.44	1.32	0.83	0.90	0.67	78.4	93.1	86.3	0.06	0.32	0.16	7.59	11.77	9.55
120	0.11	0.14	0.13	1.09	1.41	1.26	0.78	0.87	0.82	75.9	92.4	84.8	0.05	0.31	0.13	8.58	13.63	10.74
121	0.10	0.14	0.11	1.03	1.36	1.21	0.76	0.81	0.79	74.5	90.8	83.3	0.06	0.29	0.12	9.13	14.37	11.43
122	0.09	0.12	0.10	0.95	1.29	1.14	0.72	0.77	0.75	71.9	89.1	81.6	0.03	0.27	0.11	8.34	13.64	10.93
123	0.07	0.11	0.08	0.91	1.22	1.08	0.70	0.75	0.72	70.4	86.9	79.4	0.03	0.25	0.10	8.52	13.63	10.87
124	0.05	0.13	0.11	1.03	1.32	1.19	0.76	0.80	0.78	74.7	90.3	83.0	0.04	0.28	0.11	9.73	13.96	11.75
125	0.08	0.11	0.09	0.94	1.26	1.12	0.72	0.77	0.74	72.1	88.0	81.1	0.03	0.24	0.10	10.21	14.92	12.46
126	0.07	0.10	0.08	0.88	1.21	1.07	0.69	0.75	0.72	69.8	87.1	79.4	0.03	0.25	0.10	8.40	14.31	11.19
127	0.02	0.04	0.03	0.60	0.53	0.62	0.46	0.50	0.48	62.6	66.7	64.7	0.01	0.17	0.06	7.42	10.68	8.75
128	0.02	0.03	0.02	0.56	0.61	0.59	0.45	0.60	0.47	61.6	65.6	63.8	0.01	0.17	0.06	7.72	10.97	9.30
129	0.90	2.41	1.82	0.66	1.49	1.04	1.52	3.53	2.75	41.3	70.1	54.3	1.50	3.67	2.71	0.83	2.56	1.93
130	1.06	2.41	1.90	0.73	1.84	1.23	2.28	3.53	2.90	43.0	84.2	61.2	2.14	3.53	2.70	0.77	2.65	1.92
131	4.15	6.67	4.96	0.68	1.37	1.08	5.60	6.53	5.55	35.0	61.4	51.2	6.70	11.23	8.06	0.87	2.53	1.45
132	2.75	3.94	3.37	1.23	1.57	1.48	3.92	5.39	4.68	57.0	74.8	66.9	3.71	5.93	4.95	1.23	3.55	2.24
133	1.60	2.27	2.09	1.81	1.99	1.90	2.90	3.39	3.16	78.7	66.7	62.7	1.09	2.79	2.44	3.76	8.24	5.83

```
*********************************************     WATER QUALITY SUMMARY     *********************************************
      STARTS AT CYCLE     1 (  0 DAYS  0.5 HOURS)                          ENDS AT CYCLE 1000 ( 20 DAYS 20.0 HOURS)


JUNC.   CONSTITUENT 1       CONSTITUENT 2        CONSTITUENT 3         CONSTITUENT 4          CONSTITUENT 5          CONSTITUENT 6
       MIN   MAX   AVG     MIN   MAX   AVG      MIN   MAX    AVG     MIN    MAX    AVG      MIN    MAX    AVG      MIN    MAX    AVG
-------------------------------------------------------------------------------------------------------------------------------------

  1    0.05  0.05  0.05    0.10  0.10  0.10     0.20  0.20  0.20     10.0   10.0   10.0     1.00   1.00   1.00     8.00   8.00   8.00
  2    0.05  0.10  0.06    0.20  0.30  0.22     0.10  0.22  0.12     19.8   30.0   21.3     1.50   3.53   2.76     5.35   6.61   6.45
  3    0.04  0.09  0.05    0.20  0.29  0.22     0.10  0.19  0.12     19.7   30.0   22.0     1.65   2.79   2.20     4.84   6.80   5.79
  4    0.04  0.08  0.05    0.20  0.28  0.22     0.10  0.19  0.12     19.7   30.0   22.3     1.38   2.45   1.96     4.67   6.92   5.59
  5    0.02  0.08  0.05    0.20  0.27  0.22     0.05  0.18  0.12     19.6   30.0   22.6     1.30   2.22   1.76     4.39   6.80   5.29
  6    0.04  0.39  0.07    0.20  0.27  0.22     0.09  0.68  0.15     19.5   30.3   23.1     1.21   1.92   1.55     4.26   6.03   5.10
  7    0.04  0.40  0.09    0.20  0.30  0.24     0.11  0.70  0.21     20.0   31.2   24.7     1.13   1.59   1.35     4.26   6.18   5.02
  8    0.05  0.53  0.15    0.21  0.38  0.29     0.14  0.90  0.35     21.3   34.1   28.0     0.92   1.69   1.15     3.94   7.10   4.79
  9    0.10  0.91  0.31    0.25  0.53  0.41     0.32  1.36  0.66     28.7   40.0   34.3     0.75   2.16   0.97     3.18   6.76   3.91
 10    0.16  1.64  0.54    0.31  0.68  0.49     0.42  2.27  1.02     30.2   47.5   37.1     0.76   4.55   1.24     1.69   5.73   3.50
 11    0.19  1.84  0.80    0.31  0.90  0.56     0.48  2.57  1.37     30.3   47.3   39.1     0.77   4.57   1.58     0.97   5.77   3.15
 12    0.33  2.26  1.21    0.38  0.96  0.68     0.71  3.24  1.93     32.8   51.4   42.5     0.87   5.04   2.15     0.96   4.88   2.57
 13    0.52  2.49  1.65    0.45  1.21  0.82     1.12  3.58  2.50     34.5   59.0   46.5     1.20   5.40   2.74     0.33   3.45   1.95
 14    1.53  2.42  1.98    0.39  1.92  1.27     2.34  3.51  3.00     30.8   87.7   61.9     2.10   4.93   2.99     0.28   3.23   1.62
 15    1.45  2.27  1.91    0.38  1.95  1.40     2.20  3.34  2.95     29.4   89.7   67.0     1.85   4.91   2.83     0.38   3.35   1.67
 16    1.28  2.33  1.36    0.50  2.05  1.56     1.86  3.43  2.92     40.1   95.6   73.2     1.43   6.39   2.71     0.65   3.64   2.14
 17    1.24  2.17  1.70    0.59  2.06  1.66     1.60  3.28  2.75     42.0   96.7   77.7     1.74   6.96   2.46     0.68   3.71   2.32
 18    1.01  1.58  1.42    0.81  2.12  1.76     1.60  2.98  2.43     48.7  102.1   82.9     0.92   4.95   2.09     0.94   3.92   2.55
 19    0.82  1.58  1.23    1.02  2.12  1.80     1.51  2.77  2.21     55.1  104.0   85.5     0.67   4.94   1.87     0.80   4.19   2.70
 20    0.68  1.44  1.05    1.26  2.11  1.81     1.43  2.52  1.99     62.3  104.6   87.4     0.52   4.97   1.69     0.89   4.21   2.78
 21    0.55  1.32  0.89    1.38  2.11  1.80     1.27  2.32  1.81     66.1  104.5   88.7     0.39   4.78   1.55     0.92   4.54   2.89
 22    0.46  1.29  0.75    1.46  2.11  1.77     1.20  2.10  1.63     69.7  104.5   89.3     0.30   6.67   1.43     0.95   4.91   3.06
 23    0.41  1.21  0.66    1.48  2.11  1.73     1.18  1.96  1.52     68.9  104.5   89.4     0.26   6.45   1.35     1.07   5.21   3.36
 24    0.35  0.99  0.54    1.43  2.05  1.68     1.10  1.70  1.37     76.5  104.4   89.2     0.21   6.45   1.26     1.29   5.57   3.71
 25    0.24  0.81  0.43    1.33  1.97  1.58     0.96  1.51  1.22     78.2  103.9   87.0     0.13   5.53   1.18     1.56   6.10   4.14
 26    0.18  0.75  0.35    1.08  1.98  1.48     0.78  1.37  1.09     72.5  102.6   86.1     0.06   6.32   1.10     1.86   6.41   4.51
 27    0.10  0.70  0.28    1.00  1.78  1.39     0.71  1.25  0.99     70.1  100.6   84.1     0.07   6.16   1.04     2.26   6.56   4.86
 28    0.10  0.56  0.22    1.01  1.65  1.29     0.72  1.19  0.90     70.1   97.8   81.9     0.06   5.69   0.97     3.07   6.57   5.26
 29    0.10  0.30  0.16    1.00  1.43  1.17     0.70  0.95  0.80     70.0   92.2   79.2     0.05   5.05   0.90     3.60   6.96   5.39
 30    0.07  0.20  0.12    0.92  1.29  1.07     0.60  0.92  0.72     69.4   88.1   76.4     0.03   5.02   0.84     3.82   6.67   5.50
 31    0.05  0.15  0.10    0.83  1.19  0.96     0.44  0.75  0.66     65.6   85.1   73.7     0.02   4.85   0.77     4.01   6.85   5.67
 32    0.04  0.12  0.08    0.76  1.06  0.88     0.40  0.69  0.61     63.5   81.3   70.9     0.02   4.31   0.66     4.27   6.96   5.86
 33    0.03  0.10  0.06    0.64  0.95  0.79     0.40  0.63  0.56     60.5   77.7   67.8     0.02   3.69   0.60     4.58   7.23   6.13
 34    0.02  0.09  0.05    0.56  0.87  0.71     0.39  0.60  0.53     59.9   75.0   65.5     0.01   3.26   0.54     4.80   7.39   6.34
 35    0.02  0.08  0.04    0.50  0.79  0.64     0.42  0.57  0.50     55.0   71.0   62.9     0.01   3.02   0.48     5.40   7.59   6.50
 36    0.01  0.08  0.03    0.45  0.71  0.57     0.41  0.53  0.48     57.6   65.5   60.7     0.01   2.65   0.41     5.59   7.67   6.49
 37    0.01  0.06  0.03    0.39  0.67  0.51     0.40  0.50  0.45     55.5   64.9   58.7     0.01   2.14   0.36     5.60   7.30   6.32
 38    0.01  0.05  0.02    0.33  0.62  0.46     0.39  0.49  0.44     53.2   64.9   56.8     0.01   1.72   0.32     5.61   7.05   6.25
 39    0.01  0.03  0.02    0.29  0.60  0.42     0.39  0.46  0.43     51.4   65.0   54.8     0.01   1.69   0.29     5.65   7.16   6.26
 40    0.01  0.02  0.01    0.25  0.63  0.37     0.38  0.47  0.43     49.7   69.0   52.1     0.01   1.51   0.27     5.79   7.46   6.37
 41    0.00  0.02  0.01    0.20  0.54  0.32     0.38  0.58  0.44     33.2   58.5   46.5     0.01   1.33   0.24     5.94   7.69   6.50
 42    0.00  0.02  0.01    0.16  0.73  0.27     0.37  0.60  0.44     30.0   49.3   44.7     0.01   1.15   0.22     6.08   7.99   6.55
 43    0.00  0.02  0.01    0.13  0.37  0.23     0.37  0.50  0.45     29.8   47.2   41.6     0.01   1.03   0.21     6.14   8.00   6.56
 44    0.00  0.02  0.01    0.12  0.30  0.20     0.38  0.59  0.46     27.1   43.7   37.9     0.01   0.99   0.20     6.37   8.00   6.49
 45    0.00  0.01  0.01    0.09  0.33  0.17     0.38  0.60  0.47     21.1   41.9   34.5     0.00   0.99   0.19     6.30   7.59   6.41
 46    [illegible]  1.01  0.01    [illegible]  [illegible]  [illegible]     [illegible]  1.60  0.77     11.[illegible]   4[illegible].1   31.1     [illegible]   [illegible]   0.1[illegible]     6.0[illegible]   7.5[illegible]   6.3[illegible]
```

49	0.00	0.02	0.01	0.05	0.12	0.09	0.39	0.60	0.49	10.0	31.1	23.0	0.00	0.99	0.18	5.87	7.99	6.33
50	0.00	0.02	0.01	0.05	0.11	0.08	0.40	0.60	0.49	10.0	29.0	20.9	0.00	0.99	0.18	5.77	7.99	6.26
51	0.00	0.01	0.01	0.04	0.10	0.07	0.40	0.60	0.50	10.0	26.2	19.3	0.00	0.99	0.18	5.74	7.99	6.21
52	0.00	0.01	0.01	0.04	0.10	0.07	0.40	0.60	0.50	10.0	24.2	16.7	0.01	1.00	0.16	5.71	7.99	6.20
53	0.00	0.01	0.01	0.04	0.10	0.06	0.40	0.60	0.50	10.0	22.5	17.0	0.01	0.99	0.18	5.70	7.99	6.19
54	0.00	0.01	0.01	0.04	0.10	0.06	0.40	0.60	0.50	10.0	21.1	16.2	0.01	0.99	0.18	5.68	7.99	6.17
55	0.00	0.01	0.01	0.04	0.10	0.06	0.39	0.59	0.50	10.0	19.7	15.8	0.01	1.00	0.18	5.65	7.99	6.16
56	0.00	0.01	0.01	0.04	0.10	0.06	0.39	0.59	0.49	10.0	18.5	15.5	0.01	0.99	0.16	5.62	7.99	6.12
57	0.00	0.03	0.01	0.04	0.10	0.07	0.38	0.61	0.49	9.9	17.6	15.6	0.02	1.00	0.15	5.63	7.98	6.13
58	0.00	0.02	0.01	0.04	0.10	0.07	0.36	0.59	0.48	10.0	17.2	15.3	0.02	0.99	0.20	5.64	7.99	6.12
59	0.01	0.02	0.01	0.04	0.10	0.07	0.34	0.60	0.46	10.0	16.7	15.1	0.04	0.99	0.21	5.67	7.99	6.15
60	0.01	0.02	0.01	0.04	0.10	0.07	0.31	0.60	0.44	9.8	16.4	14.9	0.04	1.00	0.23	5.75	7.99	6.22
61	0.01	0.02	0.02	0.05	0.10	0.08	0.29	0.61	0.42	10.0	16.0	14.6	0.09	0.99	0.27	5.86	7.99	6.31
62	0.01	0.03	0.02	0.06	0.10	0.08	0.26	0.60	0.38	10.0	15.4	13.9	0.15	0.99	0.33	5.98	7.99	6.43
63	0.01	0.03	0.02	0.06	0.10	0.08	0.24	0.60	0.34	10.0	14.6	13.1	0.23	0.99	0.42	6.15	7.99	6.63
64	0.01	0.04	0.03	0.08	0.10	0.09	0.22	0.60	0.29	10.0	13.3	12.1	0.39	0.99	0.55	6.52	7.99	6.95
65	0.01	0.05	0.04	0.09	0.10	0.10	0.20	0.60	0.24	10.0	11.7	10.9	0.42	0.99	0.77	7.10	7.99	7.46
66	0.11	1.39	0.29	0.34	0.52	0.44	0.40	2.09	0.73	30.1	41.7	36.9	0.47	2.49	0.78	2.19	4.58	3.16
67	0.05	1.49	0.30	0.36	0.59	0.48	0.42	2.10	0.75	30.1	44.3	39.2	0.33	2.49	0.67	1.51	3.49	2.43
68	0.07	1.49	0.32	0.37	0.65	0.51	0.43	2.10	0.86	30.1	46.8	41.7	0.24	2.49	0.60	0.95	3.29	2.23
69	0.07	1.40	0.33	0.39	0.68	0.55	0.45	2.10	0.91	30.1	48.8	43.9	0.18	2.49	0.54	0.69	3.42	2.05
70	0.06	1.40	0.34	0.40	0.71	0.57	0.46	2.10	0.95	30.1	50.9	45.6	0.13	2.49	0.51	0.72	3.97	2.21
71	0.05	1.40	0.34	0.41	0.71	0.58	0.48	2.10	0.98	30.1	52.4	47.0	0.09	2.49	0.48	0.85	4.64	2.74
72	0.07	1.40	0.33	0.42	0.71	0.59	0.49	2.10	0.99	30.1	53.8	48.0	0.06	2.49	0.44	1.44	6.18	3.75
73	0.04	1.37	0.31	0.39	0.71	0.56	0.50	2.07	0.98	30.1	54.1	46.4	0.04	2.46	0.42	1.90	7.12	4.61
74	0.04	1.40	0.31	0.39	0.68	0.56	0.50	2.11	0.98	30.1	53.5	47.9	0.03	2.49	0.41	2.92	7.29	5.33
75	0.03	1.40	0.29	0.38	0.65	0.54	0.49	2.10	0.96	30.1	52.9	46.9	0.02	2.49	0.39	2.78	7.33	5.62
76	0.03	1.39	0.27	0.34	0.61	0.49	0.46	2.09	0.91	30.1	51.1	44.8	0.02	2.49	0.37	2.63	7.45	5.86
77	0.03	1.37	0.23	0.30	0.53	0.44	0.42	2.07	0.84	30.1	45.9	41.5	0.01	2.46	0.34	2.38	7.09	5.75
78	0.35	1.49	0.79	0.78	1.06	0.91	1.29	2.50	1.60	50.6	68.1	57.3	0.81	4.97	1.35	0.00	2.20	1.18
79	1.45	3.42	2.95	0.81	1.73	1.49	2.49	4.72	4.16	46.0	77.6	67.6	3.37	5.96	4.42	0.98	3.46	2.14
80	1.46	2.92	2.20	0.86	1.87	1.60	2.34	4.04	3.42	52.0	85.3	73.4	2.24	4.94	3.32	0.87	3.69	2.26
81	1.31	1.57	1.55	0.96	1.95	1.65	2.20	2.75	2.60	59.1	89.7	78.1	1.50	4.96	2.16	1.12	10.51	6.23
82	0.79	1.50	1.10	0.96	2.20	1.83	1.86	2.56	2.11	65.1	103.9	88.3	0.86	4.95	1.58	1.10	10.62	6.74
83	0.16	0.77	0.60	0.44	2.06	1.66	1.20	1.97	1.48	40.6	106.4	97.5	0.33	5.76	1.15	2.64	11.64	6.35
84	0.23	0.44	0.29	1.38	1.65	1.47	0.97	2.15	1.06	75.2	97.9	86.3	0.12	5.99	1.08	5.17	13.37	6.79
85	0.15	0.41	0.22	0.80	1.48	1.26	0.86	1.99	0.94	51.7	93.9	60.6	0.07	5.85	0.89	4.72	11.16	7.53
86	0.02	0.39	0.07	0.20	0.68	0.60	0.48	1.00	0.57	30.0	68.8	60.4	0.02	1.54	0.41	6.03	10.37	6.29
87	0.02	0.33	0.06	0.11	0.64	0.61	0.48	1.09	0.54	24.3	68.1	61.3	0.01	1.69	0.42	6.00	9.52	7.51
88	0.02	0.30	0.07	0.20	0.66	0.53	0.46	1.00	0.60	30.0	67.9	57.2	0.01	1.49	0.35	6.05	11.01	6.95
89	0.02	0.33	0.05	0.12	0.61	0.57	0.45	1.09	0.52	24.3	64.6	59.7	0.01	1.64	0.40	6.10	11.33	6.64
90	0.01	0.30	0.06	0.18	0.55	0.49	0.43	1.02	0.56	29.7	64.1	56.5	0.01	1.49	0.35	5.85	8.97	7.43
91	0.01	0.33	0.04	0.14	0.56	0.51	0.43	1.09	0.49	24.4	61.6	57.9	0.01	1.53	0.36	6.10	11.26	8.46
92	0.01	0.32	0.04	0.16	0.51	0.45	0.40	1.05	0.49	26.4	58.7	55.5	0.01	1.49	0.32	6.07	10.46	8.53
93	0.00	0.31	0.04	0.20	0.33	0.27	0.37	1.02	0.50	20.9	49.7	45.6	0.01	1.49	0.25	6.05	9.33	8.13
94	0.00	0.31	0.04	0.16	0.29	0.23	0.37	1.02	0.50	30.0	46.4	42.9	0.01	1.49	0.24	6.08	9.54	8.19
95	0.00	0.31	0.03	0.08	0.21	0.14	0.38	1.11	0.52	25.5	35.4	32.0	0.00	1.50	0.22	6.09	8.66	7.77
96	0.00	0.30	0.04	0.07	0.21	0.13	0.39	1.00	0.55	26.8	34.6	30.9	0.00	1.49	0.23	6.03	7.99	7.31
97	0.00	0.30	0.04	0.04	0.20	0.09	0.41	1.00	0.55	19.7	30.2	21.2	0.00	1.49	0.22	6.04	7.38	7.00
98	0.00	0.30	0.03	0.03	0.20	0.06	0.41	1.00	0.55	16.4	30.2	16.5	0.01	1.49	0.22	6.05	7.49	6.98
99	0.00	0.30	0.04	0.03	0.20	0.09	0.40	1.00	0.56	17.7	30.2	19.3	0.01	1.49	0.23	6.07	6.79	6.54
100	0.00	0.30	0.05	0.03	0.22	0.11	0.41	1.00	0.59	17.8	30.2	22.0	0.01	1.49	0.24	6.13	7.96	7.37
101	0.00	0.30	0.05	0.04	0.20	0.10	0.37	1.00	0.56	17.3	30.0	21.0	0.02	1.49	0.24	6.01	6.59	6.36
102	0.00	0.30	0.05	0.04	0.20	0.10	0.35	1.00	0.55	17.2	30.0	21.0	0.03	1.49	0.25	6.01	5.62	6.41
103	0.00	0.30	0.04	0.04	0.20	0.09	0.36	1.00	0.54	16.7	30.1	19.7	0.02	1.49	0.23	6.03	7.16	6.79
104	0.01	0.30	0.05	0.05	0.20	0.10	0.29	1.00	0.45	15.8	30.0	19.4	0.07	1.49	0.27	6.02	4.64	6.55
105	0.02	0.57	0.17	0.14	0.45	0.36	0.35	1.31	0.72	30.0	41.1	36.7	0.01	1.54	0.29	4.36	4.77	5.48
106	0.02	0.40	0.13	0.19	0.38	0.29	0.28	1.11	[illegible]	29.9	35.3	30.9	0.01	1.49	0.25	4.48	5.41	5.51
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.11	[illegible]	[illegible]	[illegible]	[illegible]	0.00	[illegible]	0.21	4.35	5.55	[illegible]

110	0.05	0.30	0.15	0.20	0.41	0.36	0.45	1.00	0.72	30.0	46.2	41.9	0.13	1.49	0.37	0.31	5.59	1.55
111	0.04	0.30	0.12	0.20	0.35	0.31	0.48	1.00	0.73	30.0	49.3	43.3	0.06	1.49	0.30	0.08	5.95	1.30
112	0.04	0.43	0.25	0.19	0.39	0.56	0.53	1.30	0.94	30.0	55.9	49.4	0.04	1.51	0.35	4.03	7.35	5.79
113	0.04	0.44	0.21	0.20	0.65	0.53	0.54	1.21	0.90	30.0	56.6	49.3	0.02	1.49	0.32	5.28	8.92	7.07
114	0.04	0.27	0.06	0.18	0.32	0.22	0.08	0.90	0.12	19.2	29.2	21.0	1.91	4.33	3.23	5.79	7.37	6.92
115	0.28	0.40	0.52	0.06	2.05	1.57	0.64	1.57	1.39	24.3	106.6	64.2	0.30	3.05	0.90	4.63	12.14	8.07
116	0.27	0.47	0.42	0.19	2.03	1.46	0.97	1.43	1.27	29.7	107.1	61.1	0.21	2.03	0.72	5.89	14.12	9.40
117	0.25	0.39	0.35	0.20	2.01	1.36	0.96	1.33	1.18	30.0	107.2	78.4	0.17	1.49	0.66	6.05	15.44	10.52
118	0.24	0.33	0.31	0.20	1.34	1.23	0.94	1.25	1.12	30.0	105.0	76.0	0.16	1.49	0.52	6.09	15.04	10.01
119	0.12	0.34	0.19	0.02	1.44	1.15	0.81	1.25	0.50	27.0	93.1	76.7	0.06	2.99	0.69	5.55	11.77	6.56
120	0.11	0.31	0.17	0.18	1.41	1.06	0.78	1.13	0.87	29.2	92.4	73.5	0.05	2.29	0.59	5.93	13.03	9.56
121	0.10	0.30	0.15	0.20	1.34	0.97	0.76	1.04	0.84	30.0	90.8	70.6	0.04	1.60	0.51	6.07	14.37	10.23
122	0.02	0.30	0.14	0.20	1.29	0.89	0.72	1.01	0.81	30.0	89.1	67.6	0.03	1.49	0.44	6.09	13.64	9.86
123	0.07	0.30	0.13	0.20	1.22	0.51	0.70	1.00	0.75	30.0	86.9	64.7	0.03	1.49	0.39	6.07	13.63	9.91
124	0.07	0.30	0.15	0.20	1.32	0.94	0.76	1.01	0.84	30.0	90.3	69.8	0.04	1.49	0.46	6.14	13.96	10.31
125	0.05	0.30	0.13	0.20	1.26	0.65	0.72	1.00	0.61	30.0	89.5	66.6	0.03	1.49	0.41	6.05	14.92	10.85
126	0.07	0.30	0.12	0.20	1.21	0.79	0.69	1.00	0.79	30.0	87.1	64.3	0.03	1.49	0.38	6.09	14.31	10.36
127	0.02	0.32	0.05	0.16	0.53	0.58	0.46	1.05	0.54	26.7	65.7	60.0	0.01	1.62	0.40	6.06	10.68	6.71
128	0.02	0.30	0.06	0.20	0.60	0.53	0.45	1.00	0.55	30.0	65.6	57.7	0.01	1.49	0.36	6.09	10.57	6.91
129	0.90	2.51	1.87	0.38	1.42	0.99	1.52	3.60	2.81	30.6	70.1	51.8	1.50	5.53	2.96	0.37	2.96	1.67
130	1.50	2.49	1.93	0.35	1.84	1.14	2.28	3.40	2.92	29.7	64.2	57.3	2.16	5.04	2.98	0.27	2.85	1.61
131	2.21	6.77	4.96	0.44	1.37	1.01	3.32	6.73	6.59	25.7	61.4	47.9	5.84	12.50	8.26	0.36	2.53	1.40
132	1.48	3.04	3.36	0.58	1.67	1.36	2.41	5.40	4.62	26.7	74.0	61.5	3.71	7.19	5.16	0.64	3.55	1.99
133	1.10	2.28	2.01	0.99	1.99	1.69	2.05	3.30	3.08	50.3	86.7	76.1	1.90	4.97	2.74	1.08	8.24	5.19

```
********************   SUMMARY OF DISSOLVED OXYGEN BEYOND CYCLE  500   ********************

JUNCTION     MINIMUM CONC.         MAXIMUM CONC.        AVERAGE CONC.    NO. CYCLES    NO. CYCLES    NO. CYCLES
            (MG/L)   CYCLE        (MG/L)   CYCLE          (MG/L)          DO<4         4<DO<5         DO>5
---------------------------------------------------------------------------------------------------------------

    1        9.00    1000          0.0        0            8.00
    2        6.57     672          6.78     504            6.65             0             0           501
    3        5.86     527          6.09     888            5.97             0             0           501
    4        5.54     526          5.97     898            5.72             0             0           501
    5        5.11     525          5.55     888            5.36             0             0           501
    6        4.79     526          5.28     888            5.08             0             0           501
    7        4.53     525          5.18     888            4.94             0            74           427
    8        4.04     524          5.19     888            4.69             0           369           133
    9        3.22     525          4.35     936            3.90             0           447            54
   10        2.50     525          4.25     888            3.54           331           170             0
   11        1.94     525          4.19     888            3.23           441            60             0
   12        1.31     525          3.92     868            2.71           465            36             0
   13        0.89     526          3.47     986            2.19           501             0             0
   14        0.79     531          3.23     697            1.97           501             0             0
   15        0.97     534          3.35     648            2.06           501             0             0
   16        1.42     654          3.64     696            2.62           501             0             0
   17        1.77     664          3.71     696            2.84           501             0             0
   18        2.25     864          3.92     744            3.14           501             0             0
   19        2.56     866          4.19     984            3.36           501             0             0
   20        2.69     529          4.21     984            3.49           485            16             0
   21        2.75     532          4.54     798            3.65           428            73             0
   22        2.80     535          4.91     748            3.86           364           137             0
   23        3.17     534          5.21     975            4.20           301           200             0
   24        3.45     536          5.57     975            4.55           197           258            46
   25        3.83     536          6.10     975            4.95           112           262           127
   26        4.10     537          6.41     796            5.36            16           238           247
   27        4.49     537          6.56     977            5.68             0           157           344
   28        5.22     528          6.97     982            6.06             0            75           426
   29        5.25     528          6.98     984            6.11             0             0           501
   30        5.34     528          6.97     986            6.15             0             0           501
   31        5.48     530          6.85     984            6.25             0             0           501
   32        5.63     533          6.96     975            6.40             0             0           501
   33        5.77     535          7.23     746            6.58             0             0           501
   34        5.96     535          7.39     793            6.74             0             0           501
   35        6.19     525          7.59     934            6.86             0             0           501
   36        6.11     526          7.67     984            6.80             0             0           501
   37        5.99     527          7.30     985            6.55             0             0           501
   38        5.93     529          7.00     985            6.42             0             0           501
   39        5.94     523          6.75     984            6.36             0             0           501
   40        6.06     528          6.74     984            6.42             0             0           501
   41        6.13     529          6.90     792            6.49             0             0           501
   42        6.19     529          6.90     984            6.52             0             0           501
   43        6.14     624          6.92     984            6.46             0             0           501
   44        5.07     624          6.66     934            6.32             0             0           501
   45        6.00     624          6.52     984            6.21             0             0           501
   46        6.00     624          6.33     984            6.16             0             0           501
   47        6.01     720          6.37     888            6.19             0             0           501
   48        5.97     721          6.42     984            6.17             0             0           501
   49        5.87     721          6.29     984            6.05             0             0           501
```

52	5.71	912	6.03	504	5.85	0	0	501
53	5.79	960	6.01	504	5.92	0	0	501
54	5.68	960	5.98	504	5.90	0	0	501
55	5.65	912	5.88	504	5.73	0	0	501
56	5.62	960	5.92	504	5.74	0	0	501
57	5.63	960	5.95	504	5.76	0	0	501
58	5.66	960	5.91	504	5.75	0	0	501
59	5.67	957	5.90	504	5.79	0	0	501
60	5.75	954	6.02	544	5.90	0	0	501
61	5.85	955	6.16	792	6.02	0	0	501
62	5.98	955	6.35	792	6.17	0	0	501
63	6.15	954	6.68	791	6.43	0	0	501
64	6.52	954	7.07	791	6.81	0	0	501
65	7.10	954	7.67	840	7.42	0	0	501
66	2.47	514	3.83	973	3.28	501	0	0
67	2.18	515	3.49	974	2.95	501	0	0
68	1.97	515	3.29	984	2.72	501	0	0
69	1.85	528	3.42	987	2.69	501	0	0
70	1.92	526	3.97	988	2.97	501	0	0
71	2.25	525	4.84	989	3.59	384	117	0
72	2.98	525	6.18	889	4.63	99	240	162
73	3.52	524	7.12	898	5.49	20	141	340
74	4.71	526	7.29	888	6.21	0	15	486
75	5.50	525	7.33	984	6.56	0	0	501
76	5.83	527	7.65	984	6.75	0	0	501
77	5.79	528	7.09	978	6.57	0	0	501
78	1.00	529	2.20	984	1.69	501	0	0
79	1.49	523	3.46	744	2.50	501	0	0
80	1.73	529	3.69	888	2.49	501	0	0
81	4.37	576	10.51	888	6.89	0	41	460
82	5.36	576	10.82	988	7.71	0	0	501
83	4.40	526	11.64	888	7.20	0	34	467
84	6.81	576	13.37	936	9.49	0	0	501
85	6.20	525	11.16	936	8.26	0	0	501
86	7.82	528	10.37	936	8.99	0	0	501
87	6.90	525	9.52	936	8.05	0	0	501
88	8.43	528	11.01	936	9.70	0	0	501
89	7.17	626	11.73	935	8.93	0	0	501
90	7.18	529	8.97	984	8.10	0	0	501
91	7.20	626	11.28	984	8.94	0	0	501
92	7.45	672	10.46	935	8.79	0	0	501
93	7.48	720	9.33	936	8.34	0	0	501
94	7.35	720	9.54	936	8.37	0	0	501
95	7.12	758	8.66	983	7.90	0	0	501
96	7.11	720	7.09	983	7.51	0	0	501
97	6.68	816	7.79	980	7.01	0	0	501
98	6.61	856	7.26	552	6.93	0	0	501
99	6.27	654	6.78	504	6.49	0	0	501
100	6.89	666	7.90	504	7.35	0	0	501
101	6.23	912	6.59	552	6.40	0	0	501
102	6.28	960	6.62	552	6.44	0	0	501
103	6.50	912	7.03	552	6.75	0	0	501
104	6.39	960	6.80	504	6.57	0	0	501
105	5.62	523	6.77	977	6.28	0	0	501
106	5.35	533	6.41	976	5.92	0	0	501
107	4.96	515	5.91	976	5.46	0	5	496
108	3.07	815	4.08	696	3.56	476	25	0
109	1.56	615	2.35	974	1.91	501	0	0
110	0.71	715	1.02	974	0.57	501	0	0

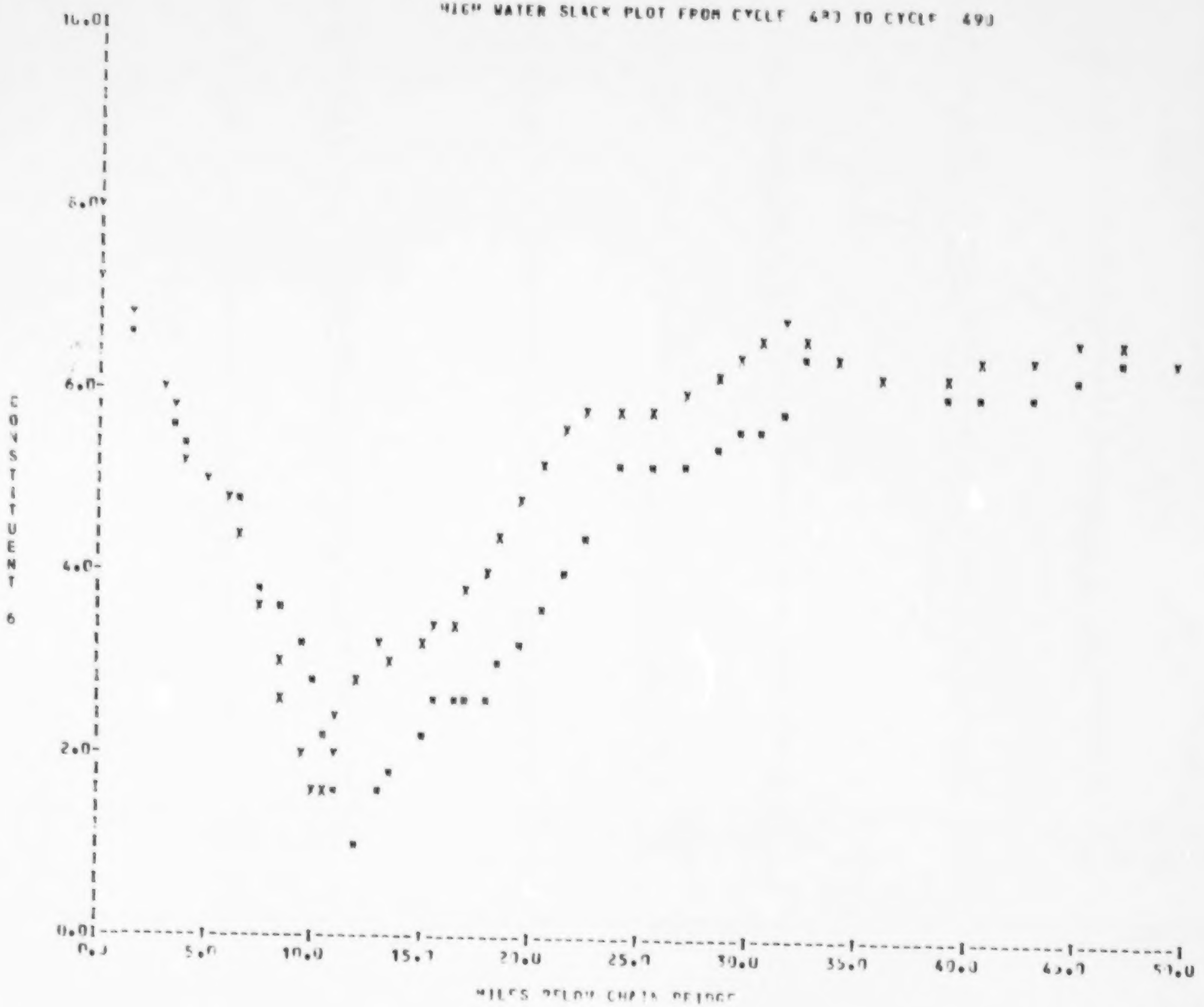
```
113      6.65   528     8.92   843      7.96      0     0   501
114      7.06   523     7.22   693      7.16      0     0   501
115      5.56   626    12.16   998      9.15      0     0   501
116      9.47   525    14.12   888     11.00      0     0   501
117      9.35   528    15.44   936     12.08      0     0   501
118      8.00   866    15.94   985     11.16      0     0   501
119      7.50   525    11.77   936      9.55      0     0   501
120      9.58   524    13.63   936     10.74      0     0   501
121      9.13   528    14.37   888     11.43      0     0   501
122      9.36   866    13.64   993     10.93      0     0   501
123      8.57   528    13.43   934     10.87      0     0   501
124      9.73   528    13.96   986     11.75      0     0   501
125     10.21   520    14.02   936     12.46      0     0   501
126      9.40   912    14.31   993     11.19      0     0   501
127      7.42   624    10.66   936      8.75      0     0   501
128      7.72   529    10.97   988      9.70      0     0   501
129      0.83   528     2.96   886      1.93    501     0   501
130      0.77   520     2.85   694      1.92    501     0     0
131      0.87   520     2.53   744      1.65    501     0     0
132      1.23   528     3.55   656      2.26    501     0     0
133      3.74   528     6.24   948      5.93     14    49   498
```

```
******************************   SUMMARY OF NUTRIENT LIMITATION BEYOND CYCLE  500   ******************************

          NO. OF CYCLES                       NO. OF CYCLES                       NO. OF CYCLES
JUNC.   N LIMITS  P LIMITS         JUNC.   N LIMITS  P LIMITS         JUNC.   N LIMITS  P LIMITS
---------------------------------------------------------------------------------------------------

   1         0         0             45       417        84             89         0       501
   2         0       501             46       501         0             90         0       501
   3         0       501             47       501         0             91         0       501
   4         0       501             48       501         0             92         0       501
   5         0       501             49       501         0             93         0       501
   6         0       501             50       501         0             94         0       501
   7         0       501             51       501         0             95       501         0
   8         0       501             52       501         0             96       501         0
   9         0       501             53       501         0             97       501         0
  10         0       501             54       501         0             98       501         0
  11       129       372             55       501         0             99       501         0
  12       224       277             56       501         0            100       501         0
  13       310       191             57       501         0            101       501         0
  14       220       281             58       501         0            102       501         0
  15       120       381             59       501         0            103       501         0
  16         0       501             60       501         0            104       501         0
  17         0       501             61       501         0            105         0       501
  18         0       501             62       501         0            106         0       501
  19         0       501             63       501         0            107         0       501
  20         0       501             64       359       142            108         0       501
  21         0       501             65         0       501            109         0       501
  22         0       501             66         0       501            110         0       501
  23         0       501             67         0       501            111         0       501
  24         0       501             68         0       501            112         0       501
  25         0       501             69         0       501            113         0       501
  26         0       501             70         0       501            114         0       501
  27         0       501             71         0       501            115         0       501
  28         0       501             72         0       501            116         0       501
  29         0       501             73         0       501            117         0       501
  30         0       501             74         0       501            118         0       501
  31         0       501             75         0       501            119         0       501
  32         0       501             76         0       501            120         0       501
  33         0       501             77         0       501            121         0       501
  34         0       501             78         0       501            122         0       501
  35         0       501             79       224       277            123         0       501
  36         0       501             80         0       501            124         0       501
  37         0       501             81         0       501            125         0       501
  38         0       501             82         0       501            126         0       501
  39         0       501             83         0       501            127         0       501
  40         0       501             84         0       501            128         0       501
  41         0       501             85         0       501            129       159       342
  42         0       501             86         0       501            130       280       221
  43        19       482             87         0       501            131       501         0
  44       193       308             88         0       501            132       345       156
                                                                      133         0       501

          NUMBER OF QUALITY CYCLES =  1000
```

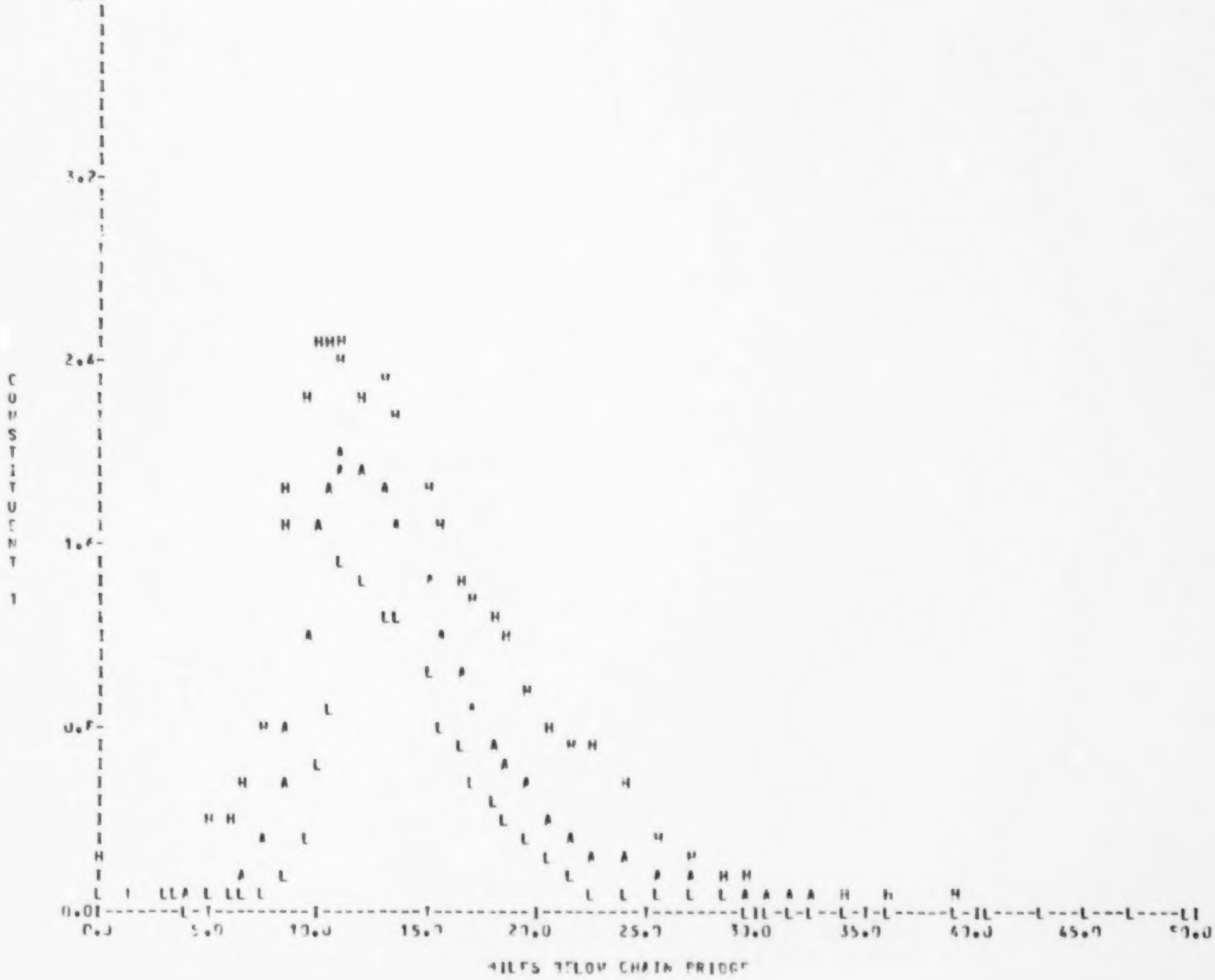
POTOMAC ESTUARY CENTER CHANNEL

LOW WATER SLACK PLOT FROM CYCLE 492 TO CYCLE 535

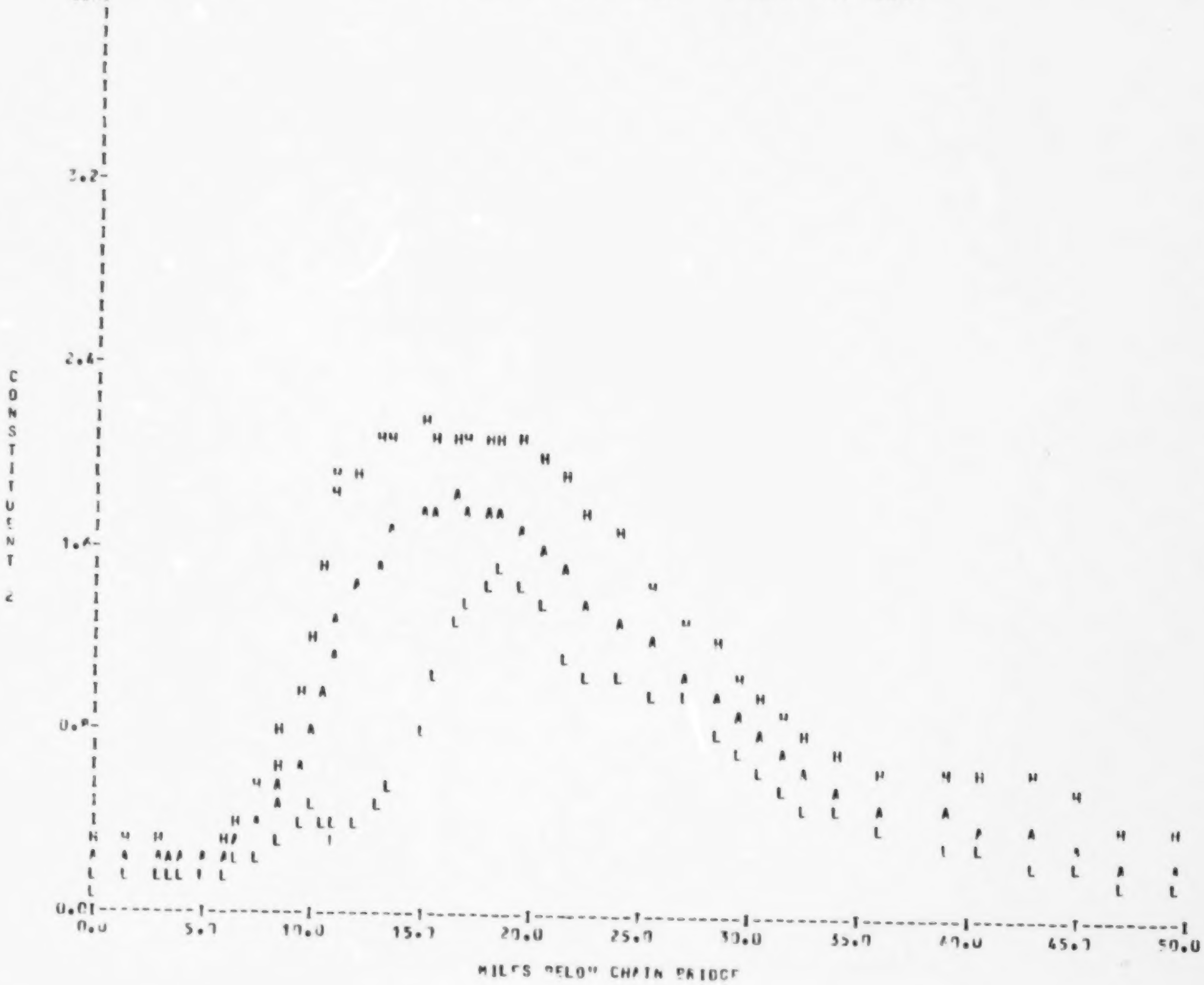
HIGH WATER SLACK PLOT FROM CYCLE 483 TO CYCLE 490



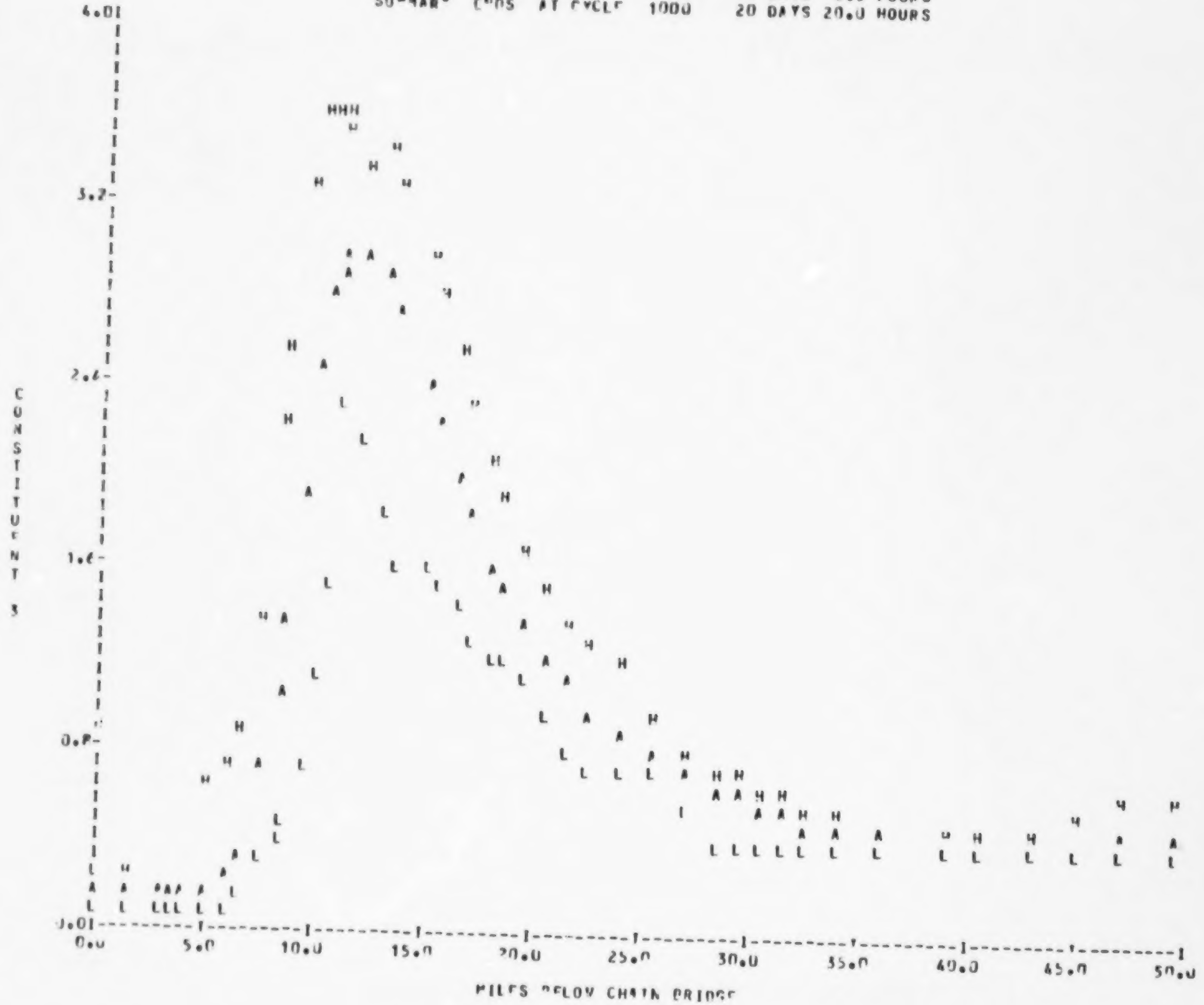
POTOMAC ESTUARY CENTER CHANNEL - QUALITY SUMMARY
SUMMARY STARTS AT CYCLE 1 0 DAYS 0.5 HOURS
SUMMARY ENDS AT CYCLE 1000 20 DAYS 20.0 HOURS



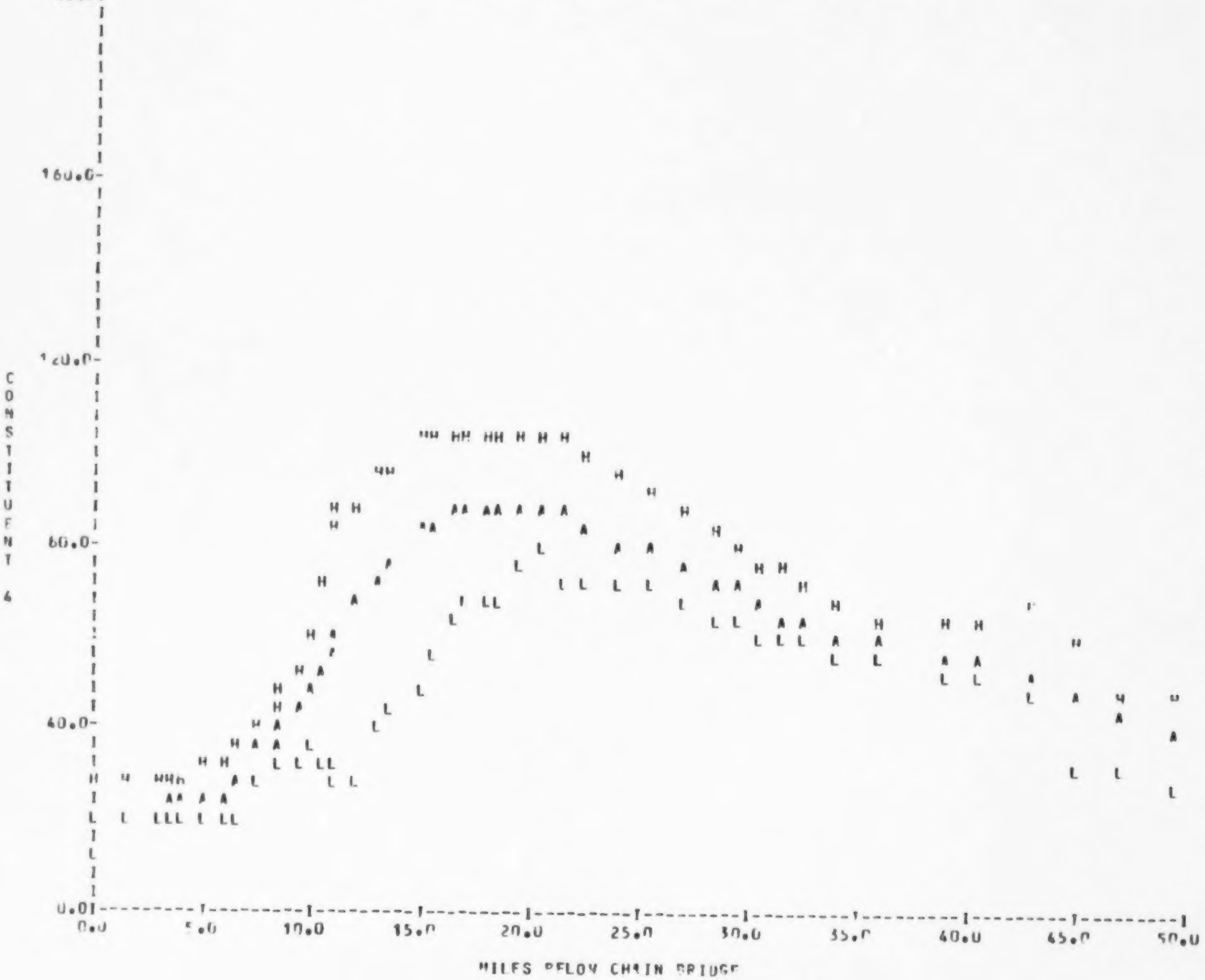
POTOMAC ESTUARY CENTER CHANNEL - QUALITY SUMMARY
SUMMARY STARTS AT CYCLE 1 0 DAYS 0.5 HOURS
SUMMARY ENDS AT CYCLE 1000 20 DAYS 20.0 HOURS



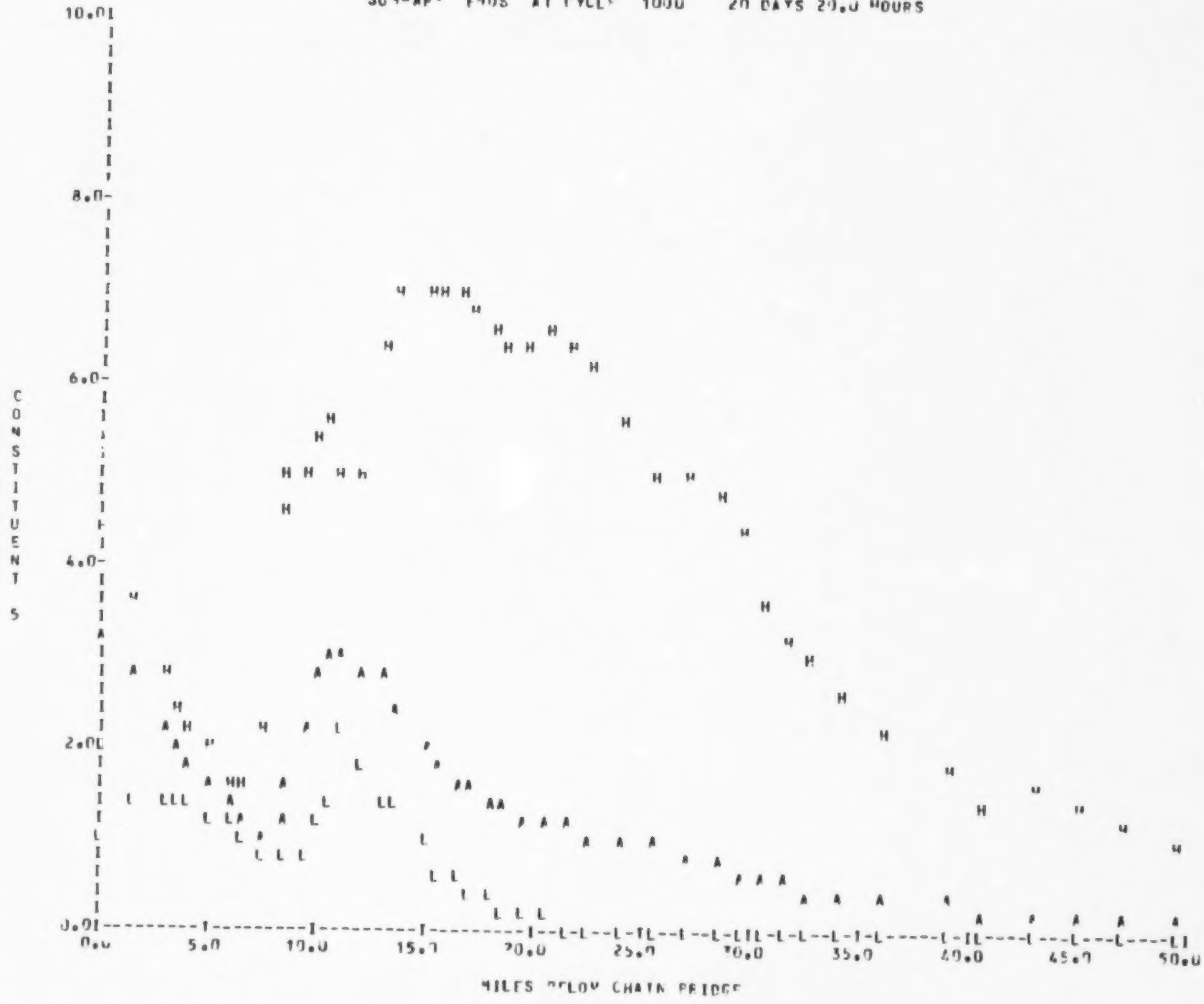
```
POTOMAC ESTUARY CENTER CHANNEL - QUALITY SUMMARY
SUMMARY STARTS AT CYCLE     1     0 DAYS  0.5 HOURS
SUMMARY ENDS  AT CYCLE  1000    20 DAYS 20.0 HOURS
```



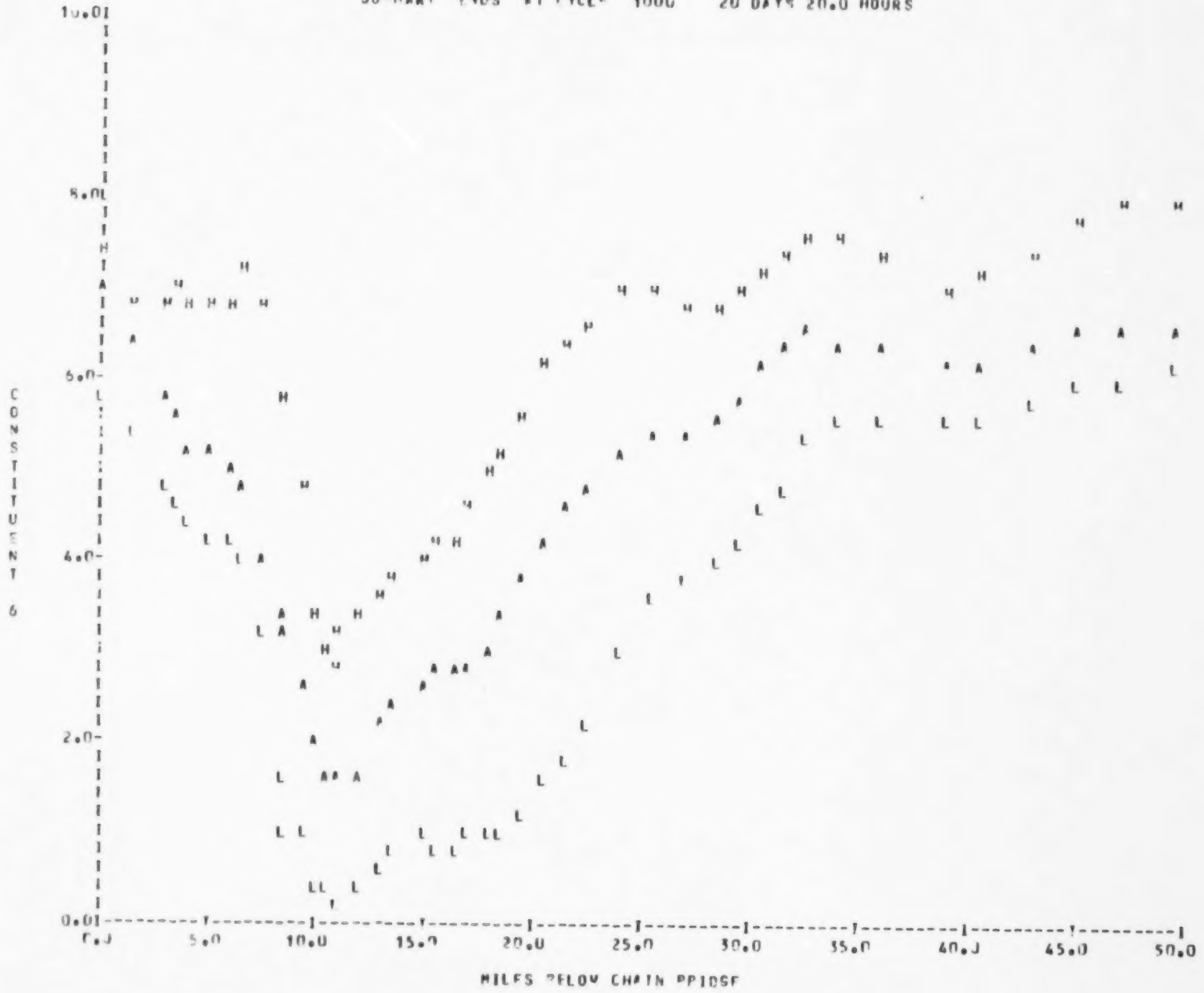
POTOMAC ESTUARY CENTER CHANNEL - QUALITY SUMMARY
SUMMARY STARTS AT CYCLE 1 0 DAYS 0.5 HOURS
SUMMARY ENDS AT CYCLE 1000 20 DAYS 23.0 HOURS



POTOMAC ESTUARY CENTER CHANNEL - QUALITY SUMMARY
SUMMARY STARTS AT CYCLE 1 0 DAYS 0.5 HOURS
SUMMARY ENDS AT CYCLE 1000 20 DAYS 20.0 HOURS



POTOMAC ESTUARY CENTER CHANNEL - QUALITY SUMMARY
SUMMARY STARTS AT CYCLE 1 0 DAYS 0.5 HOURS
SUMMARY ENDS AT CYCLE 1000 20 DAYS 20.0 HOURS



APPENDIX

A.1 REGAN LISTING

```
C******************************************************************************
C                                 PROGRAM REGAN
C                       ENVIRONMENTAL PROTECTION AGENCY
C                           ANNAPOLIS FIELD OFFICE
C******************************************************************************
C           THIS PROGRAM PERFORMS A LEAST SQUARES FIT OF AN EQUATION OF THE
C     FORM
C             Y(T) = A1 + A2*SIN(WT) + A3*SIN(2WT) + A4*SIN(3WT)
C                       + A5*COS(WT) + A6*COS(2WT) + A7*COS(3WT)
C     TO OBSERVED DATA BY SOLVING THE NORMAL EQUATIONS.
C
C******************************************************************************
C                                  DIMENSIONS
C******************************************************************************
      DIMENSION  ALPHA(40), A(7), SXX(7,7), SXY(7), T(100), X(7), Y(100)
      REAL MAXRES
C******************************** READ CONTROL DATA ***************************
      READ (5,500) (ALPHA(I), I=1,40)
      READ (5,501) NDATA, NCOEFF, MAXIT, MAXRES, PERIOD, TSHIFT, PSHIFT
C***************************  READ TIDAL INPUT DATA  **************************
      READ (5,502) (T(I), Y(I), I=1,NDATA)
      W = 2. * 3.14159 / PERIOD
C******************************  PRINT INPUT DATA  ****************************
      WRITE (6,600) (ALPHA(I), I=1,40), NDATA, NCOEFF, PERIOD, W,
     *               MAXIT, MAXRES, TSHIFT, PSHIFT
      WRITE (6,602)
      DO 100 I=1,NDATA
        WRITE (6,604) I, T(I), Y(I)
        T(I) = T(I) + TSHIFT
  100 CONTINUE
C*********************************  INITIALIZE  *******************************
      DO 104 K=1,NCOEFF
        DO 102 J=1,NCOEFF
          A(J)      = 0.
          SXY(J)    = 0.
          SXX(K,J)  = 0.
  102   CONTINUE
  104 CONTINUE
C************************** SET UP NORMAL EQUATIONS ***************************
      NC2 = NCOEFF/2 + 1
      DO 112 I=1,NDATA
        DO 106 J=1,NCOEFF
          FJ1 = FLOAT(J-1)
          FJ2 = FLOAT(J-NC2)
          IF (J.LE.NC2) X(J) = SIN(FJ1*W*T(I) + PSHIFT)
          IF (J.EQ.1)   X(J) = 1.
          IF (J.GT.NC2) X(J) = COS(FJ2*W*T(I) + PSHIFT)
          SXY(J) = SXY(J) + (X(J) * Y(I))
  106   CONTINUE
            DO 110 J=1,NCOEFF
              DO 108 K=1,NCOEFF
                SXX(K,J) = SXX(K,J) + (X(K) * Y(J))
  108         CONTINUE
  110       CONTINUE
  112 CONTINUE
C************************  PRINT NORMAL COEFFICIENTS  *************************
      WRITE (6,606)
      DO 114 J=1,NCOEFF
        WRITE (6,608) J, SXY(J), (SXX(K,J), K=1,NCOEFF)
  114 CONTINUE
```

```
C****************************  SOLVE NORMAL EQUATIONS  *****************************
      IT = 0
  115 IT = IT + 1
      RESID = 0.
        DO 118 K=1,NCOEFF
          SUM = 0.
            DO 116 J=1,NCOEFF
              IF (J.EQ.K) GO TO 116
              SUM = SUM - (A(J) * SXX(K,J))
  116       CONTINUE
          SUM = (SUM + SXY(K)) / SXX(K,K)
          DEL = ABS(SUM - A(K))
          IF (DEL.GT.RESID) RESID = DEL
          A(K) = SUM
  118   CONTINUE
      IF (IT.GE.MAXIT) GO TO 120
      IF (RESID.GT.MAXRES) GO TO 115
  120 WRITE (6,610) IT, RESID, (A(K), K=1,NCOEFF)
C****************  PRINT OBSERVED, PREDICTED, AND RESIDUAL DATA  ****************
      WRITE (6,612)
      TRES = 0.
        DO 124 I=1,NDATA
          PRED = 0.
            DO 122 J=2,NCOEFF
              FJ1 = FLOAT(J-1)
              FJ2 = FLOAT(J-NC2)
              IF (J.LE.NC2) PRED = PRED + A(J) * SIN(FJ1*W*T(I)+ PSHIFT)
              IF (J.GT.NC2) PRED = PRED + A(J) * COS(FJ2*W*T(I)+ PSHIFT)
  122       CONTINUE
          PRED = PRED + A(1)
          DIFF = PRED - Y(I)
          TRES = TRES + ABS(DIFF)
          WRITE (6,614) I, T(I), Y(I), PRED, DIFF
  124   CONTINUE
      WRITE (6,616) TRES
C*****************************  FORMAT STATEMENTS  ******************************
500   FORMAT (20A6)
501   FORMAT (3I10,4F10.0)
502   FORMAT (8F6.0)
600   FORMAT (1H1////1X,20A6,16X,'ENVIRONMENTAL PROTECTION AGENCY',/1X ,
     *20A6,16X,'LEAST SQUARES CURVE FITTING',///// ,10X,'NUMBER OF DATA
     *POINTS',10X,'NUMBER OF COEFFICIENTS',/17X,'(NDATA)',26X,'(NCOEFF)'
     *//,19X,I3,28X,I3,///// ,10X,'TIDAL PERIOD (HOURS)',11X,'OMEGA (2*P
     *I/PERIOD)',/16X,'(PERIOD)',23X,'(W)',//,17X,F5.2 ,23X,F7.4,///// ,
     *10X,'MAXIMUM NUMBER OF',14X,'MAXIMUM RESIDUAL',/10X,'ITERATIONS AL
     *LOWED',17X,'ALLOWED',//,16X,I4,26X,F6.4,///// ,10X,'TIME SHIFT',21
     *X,'PHASE ANGLE SHIFT',/11X,'(TSHIFT)',26X,'(PSHIFT)',//,12X,F5.2 ,
     *29X,F5.2   )
602   FORMAT (1H1//1X,30(1H*),'    SUMMARY OF INPUT DATA    ',30(1H*),// ,
     *20X,'OBSERVATION NO.',12X,'TIME',12X,'VALUE',/ ,15X,50(1H-)/    )
604   FORMAT (1H ,27X,I3,18X,F6.2,10X,F7.3)
606   FORMAT (1H1/// ,75X,13(1H-),/6X,'|    ------------    |',50X,'SIGMA Y
     *Y(K,J)',/4X,'|    SIGMA XY(J)     |',50X,13(1H-),/3X,'J  |  ---------
     *---    |',/6X,'|',17X,'| K =      1',14X,'2',14X,'3',14X,'4',14X,'5'
     *,14X,'6',14X,'7',/6X,'|',17(1H-),'|',105(1H-),/6X,'|',17X,'|' )
608   FORMAT (1H ,1X,I2,2X,'|',4X,F10.6,3X,'|',7(5X,F10.6),/6X,'|',17X,
     *'|' )
610   FORMAT (////50X,30(1H*),/61X,'SOLUTION',/50X,30(1H*),/// ,43X,'NUM
     *BER OF ITERATIONS',10X,'MAXIMUM RESIDUAL',//,51X,I3,26X,F7.6,////,
     *35X,'THE CURVE WHICH BEST FITS THE OBSERVED DATA IS GIVEN BY     '
     *///,20X,'Y(T)  =  ',F10.6,'  +  ',F10.6,' SIN(WT)  +  ',F10.6,' SI
     *N(2WT)  +  ',F10.6,' SIN(3WT)',//,41X,'+   ',F10.6,' COS(WT)  +  ',
     *F10.6,' COS(2WT)  +  ',F10.6,' COS(3WT)')
612   FORMAT (1H1// ,1X,30(1H*),'    SUMMARY OF OUTPUT DATA    ',30(1H*)//
     *,4X,'OBSERVATION',10X,'TIME',10X,'OBSERVED',10X,'PREDICTED',10X,'R
     *ESIDUAL',/2X ,66(1H-)// )
614   FORMAT (1H ,7X,I3,14X,F5.2,11X,F6.3,11X,F7.4,13X,F7.4)
616   FORMAT (1H ,//5X,'TOTAL RESIDUAL = ',F10.5 )
      STOP
      END
```

A.2 DYNHYD LISTING

```
C***********************************************************************
C                                 PROGRAM DYNHYD
C                         ENVIRONMENTAL PROTECTION AGENCY
C                             ANNAPOLIS FIELD OFFICE
C***********************************************************************
C         DYNHYD DESCRIBES THE DYNAMIC FLOW OF A 2-DIMENSIONAL ESTUARINE
C     SYSTEM BY OBTAINING AN EXPLICIT SOLUTION TO THE EQUATIONS OF
C     CONTINUITY AND MOMENTUM.  THIS VERSION CAN HANDLE A NETWORK OF UP
C     TO 139 CHANNELS AND 133 JUNCTIONS.
C***********************************************************************
C                                 CONTROL OPTIONS
C***********************************************************************
C     HYDEXT    = 1,0     CALL SUBROUTINE HYDEX TO CREATE A SUMMARY
C                         HYDRAULIC EXTRACT TAPE, OR NOT.
C***********************************************************************
      DIMENSION       A1(7)
      COMMON /CHAN/ AK(139), AREA(139), AREAT(139), B(139), CLEN(139),
     *              CN(139), NJUNC(139,2), Q(139), R(139), V(139),
     *              VT(139)
      COMMON /JUNC/ AREAS(133), JPRT(133), NCHAN(133,5), QIN(133),
     *              Y(133), YT(133)
      COMMON /MISC/ ALPHA(80), DELT, ICYC, INTPUN, NJ, NC, NCYC, INTRVL,
     *              NOPRT, NCYCC, PERIOD, PUNCYC
      INTEGER HYDEXT, PUNCYC
      REWIND 4
      REWIND 10
C******************************  CONTROL DATA  ******************************
      READ (5,500) (ALPHA(I), I=1,40)
      READ (5,500) HEADER
      READ (5,502) NJ, NC, NCYC, DELT, TZERO
      READ (5,504) IPRINT, INTRVL, NOPRT
      READ (5,504) (JPRT(I), I=1,NOPRT)
      READ (5,504) ITAPE, HYDEXT
      READ (5,504) PUNCYC, INTPUN
      WRITE (6,600) (ALPHA(I),I=1,40), NJ, NC, NCYC, DELT, TZERO,
     *              IPRINT, INTRVL, NOPRT, PUNCYC, INTPUN
      IF (HYDEXT.EQ.0) WRITE (6,602)
      IF (HYDEXT.EQ.1) WRITE (6,601) ITAPE
C******************************  JUNCTION DATA  *****************************
      READ (5,500) HEADER
      DO 100 J=1,NJ
      READ (5,506) JJ, Y(J), AREAS(J), QIN(J), (NCHAN(J,K), K=1,5)
        YT(J) = Y(J)
        IF (JJ.EQ.J) GO TO 100
          WRITE (6,604) JJ, J
          STOP
  100 CONTINUE
      WRITE (6,606)
      DO 102 J=1,NJ
        WRITE (6,608) J, Y(J), AREAS(J), QIN(J), (NCHAN(J,K), K=1,5)
  102 CONTINUE
```

```
C********************************  CHANNEL DATA  **********************************
      READ (5,500) HEADER
      DO 106 N=1,NC
        READ (5,508) NN, CLEN(N), B(N), AREAS(N), R(N),
     *               CM(N), V(N), (NJUNC(N,K), K=1,2)
        AREA(N) = B(N) * R(N)
        IF (NN.EQ.N) GO TO 104
          WRITE (6,610) NN, N
          STOP
  104 CONTINUE
      WRITE (6,612)
      DO 106 N=1,NC
        WRITE (6,614) N, CLEN(N), B(N), AREA(N), CM(N),
     *                V(N), R(N), (NJUNC(N,K), K=1,2)
  106 CONTINUE
C*******************  SEAWARD BOUNDARY TIDAL CONDITIONS  **********************
      READ (5,500) HEADER
      READ (5,506) MK
      READ (5,510) PERIOD, (A1(I), I=1,MK)
      WRITE (6,616) PERIOD, A1(1), (A1(I), I=1,7)
      MS = MK / 2
C**************  CHECK COMPATIBILITY OF CHANNELS AND JUNCTIONS  **************
      NEXIT = 0
      DO 112 N=1,NC
        DO 110 I=1,2
          J = NJUNC(N,I)
            DO 108 K=1,5
              IF (N.EQ.NCHAN(J,K)) GO TO 110
  108       CONTINUE
          NEXIT = NEXIT + 1
          WRITE (6,618) N, J
  110   CONTINUE
  112 CONTINUE
      DO 118 J=1,NJ
        DO 116 K=1,5
          IF (NCHAN(J,K).EQ.0) GO TO 118
          N = NCHAN(J,K)
            DO 114 I=1,2
              IF (J.EQ.NJUNC(N,I)) GO TO 116
  114       CONTINUE
          NEXIT = NEXIT + 1
          WRITE (6,618) N,J
  116   CONTINUE
  118 CONTINUE
      IF (NEXIT.GT.0) STOP
C****************  STORE CONTROL AND SYSTEM DATA ON UNIT 10  ****************
      WRITE (10) (ALPHA(I), I=1,40), NJ, NC, DELT,
     *           (CN(N), R(N), B(N), CLEN(N), N=1,NC)
      WRITE (10) (Y(J), AREAS(J), QIN(J), (NCHAN(J,K), K=1,5), J=1,NJ),
     *           (AREA(N), V(N), (NJUNC(N,I), I=1,2), N=1,NC)
```

```
C*******************************************************************************
C                                  INITIALIZATION
C*******************************************************************************
      DELT2  = DELT / 2.
      TZERO  = TZERO * 3600.
      PERIOD = PERIOD * 3600.
        W    = 2. * 3.1416 / PERIOD
        G    = 32.1739
      DO 120 N=1,NC
        AK(N) = G * (CM(N)**2 / 2.208196)
        IF (NJUNC(N,1).LT.NJUNC(N,2)) GO TO 120
          KEEP = NJUNC(N,1)
          NJUNC(N,1) = NJUNC(N,2)
          NJUNC(N,2) = KEEP
  120 CONTINUE
C*******************************************************************************
C                                   MAIN LOOP
C*******************************************************************************
      IF (IWRTE.GT.0) GO TO 124
        DO 122 N=1,NC
          Q(N) = V(N) * AREA(N)
  122   CONTINUE
        WRITE (10) IWRTE, (Y(J), J=1,NJ), (V(N), Q(N), N=1,NC)
  124 T = TZERO
      DO 166 ICYC=1,NCYC
        NCYCC = ICYC
        T2    = T + DELT2
        T     = T + DELT
C************  COMPUTE CHANNEL VELOCITY AND FLOW FOR 1/2 TIME STEP  ***********
          DO 126 N=1,NC
            NL   = NJUNC(N,1)
            NH   = NJUNC(N,2)
            R(N) = AREA(N) / B(N)
            AKT  = AK(N) / (R(N)**1.333333)
            DVDX = (1./R(N)) * (((Y(NH) - YT(NH) + Y(NL) - YT(NL))/DELT)
     *                + (V(N) / CLEN(N)) * (Y(NH) - Y(NL)))
            VT(N)= V(N) + DELT2 * ((V(N) * DVDX) - AKT * V(N)
     *                * ABS(V(N)) - (G / CLEN(N)) * (Y(NH) - Y(NL)))
            Q(N) = VT(N) * AREA(N)
  126     CONTINUE
C*****************  COMPUTE JUNCTION HEADS FOR 1/2 TIME STEP  *****************
          YT(1) = A1(1)
C              ************** SEAWARD BOUNDARY HEADS ************
          DO 128 I=1,NS
            FI   = FLOAT(I)
            YT(1) = YT(1) + A1(I+1) * SIN(FI*W*T2) +
     *                   A1(NS+1+I) * COS(FI*W*T2)
  128     CONTINUE
```

```
C             ***************** JUNCTION HEADS *******************
          DO 136 J=2,NJ
            SUMQ = QIN(J)
              DO 132 K=1,5
                IF (NCHAN(J,K).EQ.0) GO TO 134
                  N = NCHAN(J,K)
                  IF (J.NE.NJUNC(N,1)) GO TO 130
                    SUMQ = SUMQ + Q(N)
                    GO TO 132
  130             SUMQ = SUMQ - Q(N)
  132         CONTINUE
  134       YT(J) = Y(J) - ((DELT / AREAS(J)) * .5) * SUMQ
  136     CONTINUE
C****************  COMPUTE CHANNEL C.S. AREA FOR 1/2 TIME STEP  *****************
          DO 138 N=1,NC
            NL = NJUNC(N,1)
            NH = NJUNC(N,2)
            AREAT(N) = AREA(N) + .5*B(N)*(YT(NH)-Y(NH) + YT(NL)-Y(NL))
            R(N)      = AREAT(N) / B(N)
            AKT2      = AK(N) / (R(N)**1.333333)
C************  COMPUTE CHANNEL VELOCITY AND FLOW FOR FULL TIME STEP  ***********
            DVDX = (1./B(N)) * (((YT(NH)-Y(NH) + YT(NL)-Y(NL))/DELT) +
     *               (VT(N) / CLEN(N)) * (YT(NH) - YT(NL)))
            V(N) = V(N) + DELT * ((VT(N) * DVDX) -
     *                   AKT2 * VT(N) * ABS(VT(N))
     *                 - (G / CLEN(N)) * (YT(NH) - YT(NL)))
            Q(N) = V(N) * AREAT(N)
  138     CONTINUE
C******************  COMPUTE JUNCTION HEADS FOR FULL TIME STEP  *****************
          Y(1) = A1(1)
          DO 140 I=1,NS
            FI = FLOAT(I)
            Y(1) = Y(1) + A1(I+1) * SIN(FI*W*T)
     *                  + A1(NS+I+1) * COS(FI*W*T)
  140     CONTINUE
          DO 148 J=2,NJ
            SUMQ = QIN(J)
              DO 144 K=1,5
                IF (NCHAN(J,K).EQ.0) GO TO 146
                  N = NCHAN(J,K)
                  IF (J.NE.NJUNC(N,1)) GO TO 142
                    SUMQ = SUMQ + Q(N)
                    GO TO 144
  142             SUMQ = SUMQ - Q(N)
  144         CONTINUE
  146       Y(J) = Y(J) - (DELT / AREAS(J)) * SUMQ
  148     CONTINUE
C************  COMPUTE CHANNEL C.S. AREA FOR FULL TIME STEP  ********************
          DO 150 N=1,NC
            NL = NJUNC(N,1)
            NH = NJUNC(N,2)
            AREA(N) = AREAT(N) + (.5*B(N)*(Y(NH)-YT(NH) + Y(NL)-YT(NL)))
  150     CONTINUE
```

```
C******************************  CHECK VELOCITIES  ********************************
        DO 152 N=1,NC
          IF (ABS(V(N)).LT.20) GO TO 152
            WRITE (6,620) ICYC, N
            WRITE (6,622) (J, Y(J), YT(J), AREA(J), Q(J), J=1,NJ)
            L = NJ+1
            WRITE (6,624) (J, Y(J), YT(J), AREA(J), Q(J), J=L,NC)
            STOP
  152   CONTINUE
C********************  STORE DATA FOR HYDRAULIC EXTRACTS  **********************
        IF (ICYC.LT.ITAPE) GO TO 154
          WRITE (10) ICYC, (Y(J), J=1,NJ), (V(N), Q(N), N=1,NC)
  154   CONTINUE
C******************************  HYDRAULIC OUTPUT  ********************************
        IF (ICYC.NE.IPRINT) GO TO 164
          IPRINT = IPRINT + INTRVL
          TIME = T / 3600.
          WRITE (6,626) ICYC, TIME
            DO 162 I=1,NOPRT
              J = JPRT(I)
              WRITE (6,628) J, Y(J)
                DO 160 K=1,5
                  IF (NCHAN(J,K).EQ.0) GO TO 160
                    N = NCHAN(J,K)
                    IF (J.NE.NJUNC(N,1)) GO TO 156
                      VEL  = V(N)
                      FLOW = Q(N)
                      GO TO 158
  156               VEL  = -V(N)
                    FLOW = -Q(N)
  158             WRITE (6,630) N, VEL, FLOW
  160           CONTINUE
  162       CONTINUE
  164   CONTINUE
C****************************  CHECK FOR RESTART  *********************************
        IF (ICYC.EQ.PUNCYC) CALL RESTRT
  166 CONTINUE
C****************************  EXIT HYDRAULIC PROGRAM  ****************************
      WRITE (6,632) NCYCC
      IF (HYDEXT.EQ.1) CALL HYDEX
```

```
C**************************************************************************************
C                                   FORMAT STATEMENTS
C**************************************************************************************
500   FORMAT (20A4)
502   FORMAT (3I5,2F5.0)
504   FORMAT (16I5)
506   FORMAT (I5,3F10.0,5I5)
508   FORMAT (I5,2F8.0,F9.0,F7.0,2F8.0,2I5)
510   FORMAT (8F10.0)
600   FORMAT (1H1,///  ,2X,20A4,11X,'ENVIRONMENTAL PROTECTION AGENCY',/,
     *2X,20A4,3X,'DYNAMIC FLOW IN A 2-DIMENSIONAL SYSTEM',////  ,10X,'NU
     *MBER OF      NUMBER OF',/,10X,'JUNCTIONS      CHANNELS',/,13X,'(NJ)'
     *,10X,'(NC)',//,13X,I3,11X,I3,///  ,14X,'NUMBER OF          HYDRAULIC
     * TIME'/10X,'HYDRAULIC CYCLES       STEP, IN SEC.     STARTING TIME'
     *,/15X,'(NCYC)',14X,'(DELT)',11X,'(TZERO)',//16X,I4,16X,F6.1,12X,F5
     *.1,///  ,10X,'PRINTOUT BEGINS       NO. OF CYCLES        NO. OF JUNC
     *TIONS',/,13X,'AT CYCLE          BETWEEN PRINTOUT           PRINTED',/
     *,13X,'(IPRINT)',13X,'(INTRVL)',13X,'(NOPRT)',//,15X,I4,17X,I4,17X,
     *I3,///  ,10X,'RESTART DATA STORED     NO. OF CYCLES BETWEEN',/,15X
     *,'AT CYCLE',11X,'UPDATE OF RESTART DATA',/,15X,'(PUNCYC)',18X,'(IN
     *TPUN)',//,17X,I4,22X,I4,///  ,10X,'IS SUBROUTINE HYDEX         DAT
     *A FOR HYDEX IS',/,16X,'CALLED ?',10X,'STORED BEGINNING AT CYCLE',
     */,10X,'(DOES HYDEXT = 1 ?)',15X,'(ITAPE)',/   )
601   FORMAT (18X,'YES',26X,I6)
602   FORMAT (18X,'NO')
604   FORMAT(40H0JUNCTION DATA CARD OUT OF SEQUENCE. JJ= I4,4H,J= I4)
606   FORMAT (1H1//2X,48(1H*),'   SUMMARY OF JUNCTION DATA   ',50(1H*),/
     *//13X,'JUNCTION      INITIAL HEAD      SURFACE AREA      INPUT - OUTP
     *UT          CHANNELS ENTERING JUNCTION',/,10X,115(1H-),/  )
608   FORMAT (15X,I3,9X,F10.6,5X,F13.0,9X,F7.1,9X,5(6X,I3) )
610   FORMAT(39H0CHANNEL DATA CARD OUT OF SEQUENCE. NN= I4,4H,N= I4)
612   FORMAT (1H1//2X,43(1H*),'   SUMMARY OF CHANNEL DATA   ',50(1H*),//
     */10X,'CHANNEL      LENGTH       WIDTH      C.S. AREA      ROUGHNESS
     * VELOCITY      HYD. RADIUS',10X,'JUNCTIONS AT ENDS',/,9X,115(1H-)/)
614   FORMAT (12X,I3,7X,F6.0,4X,F6.0,5X,F9.1,6X,F6.3,7X,F8.5,8X,F5.1,15X
     *,I3,5X,I3 )
616   FORMAT (1H1////20X,27(1H*),'    TIDAL CONDITIONS AT THE SEAWARD BOU
     *NDARY   ',27(1H*),///,30X,'TIDAL PERIOD IS ',F5.2,' HOURS',//,30X,
     *'MEAN SEA LEVEL IS ',F8.6,' FEET',//,30X,'THE HEAD AT THE SEAWARD
     *BOUNDARY IS GIVEN BY',//,34X,'HEAD = ',F9.6,' + ',F9.6,' SIN(WT) +
     * ',F9.6,' SIN(2WT) + ',F9.6,' SIN(3WT)',/,51X,' + ',F9.6,' COS(WT)
     * + ',F9.6,' COS(2WT) + ',F9.6,' COS(3WT) '     )
618   FORMAT(30H0COMPATIBILITY CHECK. CHANNEL I4,11H, JUNCTION I4)
620   FORMAT(34H0VELOCITY EXCEEDS 20 FPS IN CYCLE I3,10H, CHANNEL I3,
     *23H, EXECUTION TERMINATED.)
622   FORMAT  (52H   NO.        Y               YT            AREA          Q//
     *       (I5,F13.6,F13.6,F15.1,F14.2))
624   FORMAT(I5,26X,F15.1,F14.2)
626   FORMAT(1H1///
     *       27H SYSTEM STATUS AFTER CYCLE I4,F12.2,6H HOURS//
     *       54H JUNCTION      HEAD      CHANNEL      VELOCITY      FLOW/
     *       54H  NUMBER       (FT)      NUMBER        (FPS)       (CFS))
628   FORMAT(1H0I5,F13.4)
630   FORMAT (1H I28,F14.5,F12.1)
632   FORMAT(42H0END OF TWO-DIMENSIONAL EXPLICIT PROGRAM. I4,8H CYCLES.)
      STOP
      END
```

```
C***********************************************************************
C                                  SUBROUTINE HYDEX
C***********************************************************************
      SUBROUTINE HYDEX
      COMMON /CHAN/ AK(139), AREA(139), AREAT(139), B(139), CLEN(139),
     *              CN(139), NJUNC(139,2), R(139), Q(139), V(139),
     *              VT(139)
      COMMON /JUNC/ AREAS(133), JPRT(133), NCHAN(133,5), QIN(133),
     *              Y(133), YT(133)
      COMMON /MISC/ ALPHA(80), DELT, ICYC, INTPUN, NJ, NC, NCYC, INTRVL,
     *              NOPRT, NCYCC, PERIOD, PUNCYC
      DIMENSION  ARAVG(139), ARMAX(139), ARMIN(139), NMAX(139),
     *    NMIN(139), QEXT(139), QMAX(139), QMIN(139), QNET(139),
     *    RANGE(133), VEXT(139), VMAX(139), VMIN(139), YAVG(133),
     *    YMAX(133), YMIN(133), YNEW(133)
      REWIND 6
      REWIND 10
C******************** READ INDEPENDENT CONTROL DATA **************************
      READ (5,500) HEADER
      READ (5,500) (ALPHA(I), I=41,80)
      READ (5,502) NODYN
C********************* READ DATA FROM HYDRAULIC PROGRAM *********************
      READ (10) (ALPHA(I), I=1,40), NJ, NC, DELT,
     *          (CN(N), R(N), B(N), CLEN(N), N=1,NC)
      READ (10) (Y(J), AREAS(J), QIN(J), (NCHAN(J,K), K=1,5), J=1,NJ),
     *          (AREA(N), V(N), (NJUNC(N,I), I=1,2), N=1,NC)
      NSTOP  = NCYCC
      NSTART = NCYCC - (PERIOD/DELT)
      DELTQ  = DELT * FLOAT(NODYN) / 3600.
      WRITE (6,600) (ALPHA(I), I=1,80)
      WRITE (6,602) NSTART, NSTOP, DELT, NODYN, DELTQ
C*********************** ALIGN TAPE AT NSTART CYCLE *************************
  100 READ (10) ICYCTF, (YNEW(J), J=1,NJ), (V(N), Q(N), N=1,NC)
      IF (ICYCTF.NE.NSTART) GO TO 100
C******************** INITIALIZE TIDAL CYCLE VARIABLES *********************
      DO 102 N=1,NC
        QNET(N)  = .5 * Q(N)
        VMAX(N)  = V(N)
        VMIN(N)  = V(N)
        QMAX(N)  = Q(N)
        QMIN(N)  = Q(N)
        ARAVG(N) = 0
        ARMAX(N) = 0
        ARMIN(N) = 1000000.
  102 CONTINUE
      DO 104 J=1,NJ
        YMIN(J) = YNEW(J)
        YMAX(J) = YNEW(J)
        NMIN(J) = ICYCTF
        NMAX(J) = ICYCTF
        YAVG(J) = .5 * YNEW(J)
  104 CONTINUE
C***************** INITIALIZE INTER-TIDAL CYCLE VARIABLES ******************
  106 DO 108 N=1,NC
        QEXT(N) = .5 * Q(N)
        VEXT(N) = .5 * V(N)
  108 CONTINUE
      WRITE (6) ICYCTF, (YNEW(J), J=1,NJ)
```

```
C**********************  COMPUTE INTER-TIDAL PARAMETERS  **********************
      DO 126 IC=1,NODYN
        READ (10) ICYCTF, (YNEW(J), J=1,NJ), (V(N), Q(N), N=1,NC)
          DO 118 N=1,NC
C             ***************** SUMMATIONS ********************
            QEXT(N) = QEXT(N) + Q(N)
            VEXT(N) = VEXT(N) + V(N)
            QNET(N) = QNET(N) + Q(N)
C             ************** CROSS-SECTIONAL AREA **************
            IF (V(N).NE.0.) GO TO 110
              NL = NJUNC(N,1)
              NH = NJUNC(N,2)
              AREA(N) = AREA(N)
     *                  + .5 * B(N) * (YNEW(NH)-Y(NH) + YNEW(NL)-Y(NL))
              GO TO 112
  110       AREA(N) = Q(N) / V(N)
  112       ARAVG(N)= ARAVG(N) + AREA(N)
C             ************* MIN AND MAX VELOCITIES *************
            IF (V(N).GT.VMIN(N)) GO TO 113
              VMIN(N) = V(N)
              GO TO 114
  113       IF (V(N).GT.VMAX(N)) VMAX(N) = V(N)
  114 CONTINUE
C             *************  MIN AND MAX C.S. AREAS  ***********
            IF (AREA(N).GT.ARMIN(N)) GO TO 115
              ARMIN(N) = AREA(N)
              GO TO 116
  115       IF (AREA(N).GT.ARMAX(N)) ARMAX(N) = AREA(N)
  116       CONTINUE
  118     CONTINUE
C             *************** MIN AND MAX HEADS ****************
          DO 124 J=1,NJ
            IF (YNEW(J).GT.YMIN(J)) GO TO 120
              YMIN(J) = YNEW(J)
              NMIN(J) = ICYCTF
  120       IF (YNEW(J).LT.YMAX(J)) GO TO 122
              YMAX(J) = YNEW(J)
              NMAX(J) = ICYCTF
  122       CONTINUE
            YAVG(J) = YAVG(J) + YNEW(J)
              Y(J)  = YNEW(J)
  124     CONTINUE
  126 CONTINUE
C     ****************** INTER-TIDAL FLOW AND VELOCITY *****************
      DO 132 N=1,NC
        QEXT(N) = QEXT(N) - .5 * Q(N)
        QEXT(N) = QEXT(N) / FLOAT(NODYN)
        VEXT(N) = VEXT(N) - .5 * V(N)
        VEXT(N) = VEXT(N) / FLOAT(NODYN)
C               *************** MIN AND MAX FLOW ****************
        IF (QEXT(N).GT.QMIN(N)) GO TO 128
          QMIN(N) = QEXT(N)
          GO TO 130
  128   IF (QEXT(N).GT.QMAX(N)) QMAX(N) = QEXT(N)
  130   CONTINUE
  132 CONTINUE
      WRITE (4) (QEXT(N), VEXT(N), N=1,NC)
      IF (ICYCTF.NE.NSTOP) GO TO 106
```

```
C**************************  COMPUTE TIDAL SUMMARY  ****************************
      DO 134 N=1,NC
        QNET(N)  = QNET(N) - .5 * Q(N)
        QNET(N)  = QNET(N) / FLOAT(NSTOP-NSTART)
        ARAVG(N) = ARAVG(N) / FLOAT(NSTOP-NSTART)
         R(N)    = ARAVG(N) / B(N)
  134 CONTINUE
      DO 136 J=1,NJ
        RANGE(J) = YMAX(J) - YMIN(J)
        YAVG(J)  = YAVG(J) - .5 * YNEW(J)
        YAVG(J)  = YAVG(J) / FLOAT(NSTOP-NSTART)
  136 CONTINUE
C***************** COMPLETE WRITING HYDRAULIC EXTRACT TAPE ********************
      WRITE (4) (QNET(N), N=1,NC)
      WRITE (4) (ALPHA(I), I=1,40), NJ, NC, DELT,
     *          (CN(N), R(N), B(N), CLEN(N), N=1,NC)
      WRITE (4) (YAVG(J), AREAS(J), QIN(J), (NCHAN(J,K),K=1,5), J=1,NJ),
     *          (ARAVG(N), (NJUNC(N,I), I=1,2), N=1,NC)
C************************  PRINT TIDAL CYCLE SUMMARY  *************************
      WRITE (6,604) (N, QNET(N), QMIN(N), QMAX(N), VMIN(N), VMAX(N),
     *               ARMIN(N), ARMAX(N), ARAVG(N), N=1,NC)
      WRITE (6,606) (J, YMIN(J), NMIN(J), YMAX(J), NMAX(J), YAVG(J),
     *               RANGE(J), J=1,NJ)
C**********************  CHECK HYDRAULIC EXTRACT TAPE  *************************
      REWIND 4
      K = (NSTOP - NSTART) / NODYN
      WRITE (6,608)
      DO 138 I=1,K
        READ (4) ICYCTF, (YNEW(J), J=1,NJ)
        READ (4) (QEXT(N), VEXT(N), N=1,NC)
        WRITE (6,610) ICYCTF, YNEW(1), YNEW(50), YNEW(30), YNEW(10),
     *                 YNEW(114), QEXT(65), QEXT(50), QEXT(30), QEXT(10),
     *                 QEXT(1)
  138 CONTINUE
```

```
C*****************************************************************************************
C                                    FORMAT STATEMENTS
C*****************************************************************************************
500   FORMAT (20A4)
502   FORMAT (16I5)
600   FORMAT (1H1///
     *  1H 20A4,10X,37H FEDERAL WATER QUALITY ADMINISTRATION/
     *  1H 20A4,10X,32H NET FLOWS AND HYDRAULIC SUMMARY/
     *        1H 20A4/1H 20A4////)
602   FORMAT(89H ******** FROM HYDRAULICS PROGRAM ********      HYDRAULIC
     * CYCLES PER      TIME INTERVAL IN/
     *87H START CYCLE   STOP CYCLE     TIME INTERVAL         QUALITY CYCLE
     *          QUALITY PROGRAM//
     *1H I7,I14,F11.0,9H  SECONDS,10X,I6,12X,F9.2,7H  HOURS/////)
604   FORMAT(119H                                  * * * * *  FLOW  * * * * *
     *     * *   VELOCITY   * *       * * *  CROSS-SECTIONAL AREA  * * */
     *       119H CHANNEL      NET FLOW          MIN.              MAX.
     *      MIN.           MAX.              MIN.          MAX.          AVE./
     *       119H NUMBER         (CFS)             (CFS)             (CFS)
     *     (FPS)          (FPS)          (SQ. FT)      (SQ. FT)     (SQ. FT)/,
     *1X,120(1H-),/,(1H I5,F15.2,2F16.2,2F13.3,F16.1,F13.1,F12.1))
606   FORMAT (1H1,/// ,1X,50(1H*),'    SUMMARY OF JUNCTION HEADS    ',50(1
     *H*),//// ,16X,'JUNCTION      MINIMUM HEAD      CYCLE  OF      MAXIMUM
     * HEAD      CYCLE OF      AVERAGE HEAD      TIDAL RANGE',/,31X,'(FT)',
     *9X,'OCCURENCE',9X,'(FT)',9X,'OCCURENCE',9X,'(FT)',12X,'(FT)',/ ,10
     *X,115(1H-),/,(1H ,16X,I3,11X,F6.2,11X,I4,10X,F6.2,10X,I4,11X,F6.2,
     *10X,F6.2))
608   FORMAT (1H1///10X,30(1H*),'     CHECK HYDRAULIC EXTRACT TAPE     ',
     *30(1H*),//3X,'CYCLE',15X,'HEADS AT JUNCTIONS',36X,'FLOWS IN CHANNE
     *LS',//14X,'1',7X,'50',6X,'30',6X,'10',5X,'114',16X,'65',11X,'50',
     *11X,'30',11X,'10',10X,'1',/,1X,125(1H-),/ )
610   FORMAT (3X,I4,2X,5(3X,F5.2),8X,5(3X,F10.2) )
      RETURN
      END
```

```
C*******************************************************************************
C                                  RESTRT
C*******************************************************************************
      SUBROUTINE RESTRT
      COMMON /CHAN/ AK(139), AREA(139), AREAT(139), B(139), CLEN(139),
     *              CN(139), NJUNC(139,2), Q(139), R(139), V(139),
     *              VT(139)
      COMMON /JUNC/ AREAS(133), JPRT(133), NCHAN(133,5), QIN(133),
     *              Y(133), YT(133)
      COMMON /MISC/ ALPHA(80), DELT, ICYC, INIPUN, NJ, NC, NCYC, INTPVL,
     *              NOPRT, NCYCC, PERIOD, PUNCYC
      IF (ICYC.EQ.NCYC) GO TO 10
C***************************  WRITE RESTART TAPE  ****************************
        PUNCYC = PUNCYC + INTPUN
        WRITE (4) ICYC, (Y(J), YT(J), J=1,NJ), (V(N), AREA(N), N=1,NC)
        REWIND 4
        GO TO 30
C***************************  PUNCH RESTART DECK  ****************************
   10 WRITE (8,60) (J, Y(J), AREAS(J), QIN(J),(NCHAN(J,K),K=1,5),J=1,NJ)
      WRITE (8,61) (N, CLEN(N), B(N), AREA(N), R(N),
     *              CN(N), V(N), (NJUNC(N,K),K=1,2),N=1,NC)
   20 TZERO2 = T / PERIOD
      KTZERO = TZERO2
      TZERO2 = (T/3600.) - FLOAT(KTZERO) * (PERIOD/3600.)
      WRITE (6,62) ICYC, TZERO2
   30 CONTINUE
C***************************  PRINT RESTART DATA  ****************************
C                 ***************  JUNCTIONS  **************
      WRITE (6,63)
      WRITE (6,64) (J, Y(J), AREAS(J), QIN(J),(NCHAN(J,K),K=1,5),J=1,NJ)
C                 ***************  CHANNELS  ***************
      WRITE (6,65)
      WRITE (6,66) (N, CLEN(N), B(N), AREA(N), CN(N), V(N),
     *              R(N), (NJUNC(N,K), K=1,2), N=1,NC)
C***************************  FORMAT STATEMENTS  *****************************
   60 FORMAT (I5, F10.4, F10.0, F10.2, 5I5)
   61 FORMAT (I5, 2F8.0, F9.1, F7.3, F8.3, F8.5, 2I5)
   62 FORMAT (1H1///5X,'RESTART TAPE WAS LAST WRITTEN AT CYCLE',I4,5X,'
     * TZERO FOR RESTARTING = ',F10.7 )
   63 FORMAT (1H1///
     *        32H  JUNCTION DATA FOR RESTART DECK///)
   64 FORMAT (54H JUNCTION   INITIAL HEAD   SURFACE AREA   INPUT-OUTPUT
     *     CHANNELS ENTERING JUNCTION//(1H ,I6,F15.4,F17.0,F11.2,I13,
     *     4I6))
   65 FORMAT (1H1///
     *        31H  CHANNEL DATA FOR RESTART DECK///)
   66 FORMAT ( 97H CHANNEL   LENGTH   WIDTH     AREA    MANNING   VELOCI
     *TY   HYD RADIUS           JUNCTIONS AT ENDS//
     *(1H I5,F11.0,F8.0,F10.1,F9.3,F10.5,F13.2,      I23,I6))
      RETURN
      END
```

A.3 DYNQUAL LISTING

```
C*************************************************************************************
C                               PROGRAM DYNQUAL
C                      ENVIRONMENTAL PROTECTION AGENCY
C                           ANNAPOLIS FIELD OFFICE
C                         DYNAMIC WATER QUALITY MODEL
C*************************************************************************************
C      THIS DECK HAS BEEN REVISED FOR APPLICATION TO THE POTOMAC ESTUARY
C      THE MODEL NETWORK CONSISTS OF UP TO 133 JUNCTIONS AND 139 CHANNELS
C                THIS IS A GENERAL 6 CONSTITUENT D.O. BUDGET MODEL
C           THIS VERSION ALSO CONTAINS A GENERALIZED PLOTTING PACKAGE
C*************************************************************************************
C       THIS MODEL PREDICTS CHLOROPHYLL YIELD BASED UPON EITHER NITROGEN
C    OR PHOSPHORUS UTILIZATION. IN ADDITION, IT CAN CONSIDER BOTH
C    NUTRIENTS SIMULTANEOUSLY IN THE PRODUCTION OF CHLOROPHYLL AND THEN
C    DETERMINE WHICH IS RATE LIMITING BY COMPARING INDIVIDUAL THEORETICAL
C    CHLOROPHYLL YIELD ACCORDING TO FIRST-ORDER KINETICS.
C       SOLUBLE FRACTIONS OF NITROGEN AND PHOSPHORUS ARE CONSIDERED IN
C    THE MODEL. REGENERATION OF PARTICULATE NITROGEN AND/OR PHOSPHORUS IN
C    THE DECAYING ALGAE TO SOLUBLE FORMS MAY ALSO BE INCLUDED. ALGAL CBOD
C    MAY ALSO BE REGENERATED BY FIRST-ORDER KINETICS. ALL REACTION RATES
C    MAY BE VARIED SPATIALLY. THIS VERSION ALSO INCLUDES THE EFFECTS OF
C    THIS CHLOROPHYLL PRODUCTION, AS WELL AS OTHER MAJOR COMPONENTS OF
C    THE D.O. BUDGET. A REAL TIME CLOCK IS INCLUDED FOR THE PHOTO-PERIOD.
C       WASTEWATER INPUTS, NON-POINT SOURCES (BANK LOADS), AND UPPER
C    BOUNDARY INPUTS CAN ALL BE VARIED WITH TIME. LOADINGS ARE READ IN
C    FOR EACH JUNCTION AS NECESSARY.
C       OUTPUT OPTIONS INCLUDE PRINTOUT OF SNAPSHOT TABLES, SLACK WATER
C    TABLES (FIRST CYCLE MUST BE SPECIFIED), TIDAL CYCLE SUMMARIES, AND
C    PLOTS OF THE ABOVE TABLES (AS WELL AS TIME PLOTS FOR ANY JUNCTION).
C       TWO PHOSPHORUS LOSS RATES ARE INCLUDED IN THE MODEL. PHYSICAL
C    DEPOSITION (DECAY) IS A SECOND-ORDER REACTION RATE. BIOLOGICAL
C    UPTAKE (PHUP) IS A FIRST-ORDER REACTION RATE.

C*************************************************************************************
C                                CONTROL OPTIONS
C*************************************************************************************

C IREOXK    = 1,2,3,4    REOXYGENATION RATE IS COMPUTED BY
C                        O'CONNOR-DOBBINS EQUATION,COMPUTED BY CHURCHILL
C                        EQUATION, OR COMPUTED BY USGS EQUATION, OR
C                        CONSTANT
C SEACON(K) = 1,2        SEAWARD BOUNDARY CONCENTRATIONS FOR CONSTITUENT
C                        'K' ARE CONSTANT, OR VARIABLE OVER TIDAL CYCLE
C KDCOP     = 0,1        DEPLETION CORRECTIONS ARE NOT, OR ARE PRINTED
C KPLOP     = 0,1,2,3    NO BACKGROUND GRID ON PLOTS, LOW DENSITY GRID,
C                        MEDIUM DENSITY GRID, OR HIGH DENSITY GRID
C KPLOT     = 0,1,3,4    NO PLOT, PLOT, PREPARE OVERLAY FOR CONST 6,
C                        PERFORM OVERLAY FOR CONST 6
C KREAC     = 1,2,3      NITROGEN UPTAKE ONLY, PHOSPHORUS UPTAKE ONLY,
C                        OR UPTAKE OF NITROGEN AND PHOSPHORUS
C KSL       = 0,1,2      PRINT SNAPSHOT TABLE, HIGH WATER SLACK TABLE,
C                        OR LOW WATER SLACK TABLE
C MIX       = 1,2,3,4,5  ADVECTED CONCENTRATIONS COMPUTED USING THE
C                        UPSTREAM, 1/2 POINT, 1/3 POINT, 1/4 POINT, OR
C                        2 - WAY PROPORTIONAL METHOD
```

```
C***********************************************************************
C                     DIMENSION STATEMENTS + COMMON BLOCKS
C***********************************************************************
C
C- - - - - - - - - - - - - - MISC. QUALITY PARAMETERS - - - - - - - - - - - - -
      DIMENSION AMUP(133), AMUPP(133), DECAY(133,6), DECAYK(10,6),
     *    DAMUP(133), DDECAY(133,6), DPHUP(133), DREBOD(133),
     *    DREGEN(133), DREGEP(133), PHUP(133), PHUPP(10), REBOD(133),
     *    REBODD(10), REGEN(133), REGENN(10), REGEP(133), REGEPP(10),
     *    SEACON(6), THETA(6), DMASSD(133)
      DIMENSION  ALPHA(80), BACKC(4), CIN(6,133), CINT(6), CLIMIT(6),
     *    CDIFFK(10), CNAME(12), NMPL(133), NPPL(133), NFC(10),
     *    NLC(10), NF1(10), NF2(10), NF3(10), NL1(10), NL2(10), NL3(10)
C- - - - - - - - - - - - DISSOLVED OXYGEN PARAMETERS - - - - - - - - - - - - -
      DIMENSION DOAVG(133), BENTH(133), BENT(10), DEPTH(10),
     *    DEPTMP(133), DOLT4(133), DO4TO5(133), DOGT5(133), DOMAX(133),
     *    DOMIN(133), MAXCYC(133), MINCYC(133), PHOTO(133), PHOT(10),
     *    RESP(133), RES(10)
C- - - - - - - - - - - - - CONSTANT WASTE INPUTS - - - - - - - - - - - - - - -
      DIMENSION  CONCW(133,6), CWC(20,6), CWLOAD(133,6), JRCW(20),
     *    QCW(20), QIN(133), QINWQ(133), VOLQIN(133), XLOAD(20,6)
C- - - - - - - - - - - - - VARIABLE WASTE INPUTS - - - - - - - - - - - - - - -
      DIMENSION  CON(6,20,20), FLO(20,20), INCDUR(20,20), JRVW(20),
     *    KCYC(20), KINC(20), NINC(20), VWLOAD(6)
C- - - - - - - - - - - - - - - BANK LOAD INPUTS - - - - - - - - - - - - - - -
      DIMENSION  BCON(20,6), ICYC1(20), ICYC2(20), JRBL1(20),
     *    JRBL2(20), SLINE(133), TBFLOW(20,133), VBLOAD(6)
C- - - - - - - - - - - - - INPUT/OUTPUT PARAMETERS - - - - - - - - - - - - - -
      DIMENSION  IPRT1(20), IPRT2(20), LPRT1(20), LPRT2(20),
     *    IPLT1(20), IPLT2(20)
C- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      COMMON /CHAN/   AREA(139), B(139), CLEN(139), CN(139), DIFFK(139),
     *                NJUNC(139,2), Q(139), QNET(139), R(139), V(139)
      COMMON /JUNC/   ASUR(133), AVOL(133), NCHAN(133,5), VOL(133),
     *                Y(133), YNEW(133)
      COMMON /QUAL/   C(133,6), CMASS(133,6)
      COMMON /MISC/   CTIME, DELTQ, ICYC, NC, NJ, NPP, NUMCON,
     *                RMNODE(133), STIME
      COMMON /SCALES/ XMAX, XMIN, YMAX, YMAXC(6), YMIN, YMINC(6)
      COMMON /SLACK/  JPRT(150,5), KSL(20), KPLOT(20), NFPC(20),
     *                NLPC(20), NOPRT(150), NCONSW(5), NSWP
      COMMON /OBSDAT/ OBDATA(3,6,20), RMDATA(20), NDATA, NOBCYC(10)
      COMMON /GRID/   KPLOP
      COMMON /TIMEPL/ JUNCTP(20), NCITP(20), NCONTP(20,6), NECTP(20),
     *                NSCTP(20), NTP
      REAL    MCHLOM, MCHLOP, NITCHL
      INTEGER DOLT4, DO4TO5, DOGT5, HYDCYC, SEACON
```

```
C***********************************************************************
C                   READ SYSTEM INFORMATION FROM HYDRAULIC TAPE
C***********************************************************************

      REWIND 3
      REWIND 4
      READ (5,508) (ALPHA(I), I=41,80)
      READ (5,500) NJ, NC, NSTART, NSTOP, NODYN
      K = (NSTOP - NSTART) / NODYN
        DO 100 I=1,K
          READ (4)  ICYCTF, (YNEW(J), J=1,NJ)
          READ (4)  (Q(N), V(N), N=1,NC)
          WRITE (3) ICYCTF, (YNEW(J), J=1,NJ)
          WRITE (3) (Q(N), V(N), N=1,NC)
  100   CONTINUE
      READ (4) (QNET(N), N=1,NC)
      READ (4) (ALPHA(I), I=1,40), NJ, NC, DELT,
     *         (CM(N), R(N), B(N), CLEN(N), N=1,NC)
      READ (4) (T(J), ASUR(J), QIN(J), (NCHAN(J,K),K=1,5),J=1,NJ),
     *         (AREA(N), (NJUNC(N,I), I=1,2), N=1,NC)
      REWIND 3
      REWIND 4

C***********************************************************************
C                          READ INDEPENDENT CONTROL DATA
C***********************************************************************

      READ (5,508) HEADER
      READ (5,500) HYDCYC, NQCYC, NUTCYC, NDOCYC, NSPEC
      READ (5,500) NUMCON, KDCOP, KREAC, MIX
      READ (5,504) TEMP, STIME

C*************************   TABULAR OUTPUT CONTROL   *************************

      READ (5,508) HEADER
      READ (5,500) NSUM1,NPLT1
      IF (NSUM1.EQ.0) GO TO 102
        DO 102 N=1,NSUM1
          READ (5,500) IPRT1(N), LPRT1(N), IPLT1(N)
  102   CONTINUE
      READ (5,500) NSUM2, NPLT2
      IF (NSUM2.EQ.0) GO TO 104
        DO 104 N=1,NSUM2
          READ (5,500) IPRT2(N), LPRT2(N), IPLT2(N)
  104   CONTINUE
      READ (5,500) NSWTAB
      IF (NSWTAB.EQ.0) GO TO 106
        DO 106 N=1,NSWTAB
          READ (5,500) NFPC(N), KSL(N), KPLOT(N)
  106   CONTINUE

C*************************   PLOTTING OUTPUT CONTROL   *************************

      READ (5,508) HEADER
      READ (5,500) NTP, NSWP, KPLOP
      READ (5,500) NDATA, NOBDAT
      IF (NOBDAT.GT.0) READ (5,500) (NOBCYC(I), I=1,NOBDAT)
      IF (NSWP.GT.0) READ (5,500) (NCOMSW(K), K=1,NUMCON)
      IF (NTP.EQ.0) GO TO 110
        DO 108 N=1,NTP
        READ (5,500) JUNCTP(N), NSCTP(N), NECTP(N), NCITP(N),
     *              (NCONTP(N,K),K=1,NUMCON)
108     CONTINUE
110  CONTINUE
     NUMPLT = NSWP + NTP + NPLT1 + NPLT2
     IF (NUMPLT.EQ.0) GO TO 114
     READ (5,506) (YMAXC(K), YMINC(K), K=1,NUMCON)
        DO 112 K=1,NUMCON
          YMAXC(K) = YMAXC(K) - .1
112     CONTINUE
     IF (NUMPLT.EQ.NTP) GO TO 114
              RMNODE (114) =  0.0
              RMNODE (  2) =  1.5
              RMNODE (  3) =  2.8
              RMNODE (  4) =  3.3
              RMNODE (  5) =  4.1
              RMNODE (  6) =  4.8
              RMNODE (  7) =  5.9
              RMNODE (  8) =  6.6
              RMNODE (  9) =  7.6
              RMNODE ( 10) =  8.4
              RMNODE ( 11) =  8.7
              RMNODE ( 12) =  9.4
              RMNODE ( 13) =  9.9
              RMNODE (129) = 10.3
              RMNODE (130) = 10.8
              RMNODE ( 16) = 11.2
              RMNODE ( 15) = 12.0
              RMNODE ( 16) = 12.9
              RMNODE ( 17) = 13.6
              RMNODE ( 18) = 14.8
              RMNODE ( 19) = 15.3
              RMNODE ( 20) = 16.3
              RMNODE ( 21) = 16.9
              RMNODE ( 22) = 17.9
              RMNODE ( 23) = 18.5
              RMNODE ( 24) = 19.5
              RMNODE ( 25) = 20.4
              RMNODE ( 26) = 21.4
              RMNODE ( 27) = 22.3
              RMNODE ( 28) = 24.0
              RMNODE ( 29) = 25.7
              RMNODE ( 30) = 27.0
              RMNODE ( 31) = 28.5
              RMNODE ( 32) = 29.6
              RMNODE ( 33) = 30.7
              RMNODE ( 34) = 31.4
              RMNODE ( 35) = 32.7
              RMNODE ( 36) = 34.2
              RMNODE ( 37) = 36.2
              RMNODE ( 38) = 38.8
              RMNODE ( 39) = 40.6
              RMNODE ( 40) = 42.9
              RMNODE ( 41) = 45.0
              RMNODE ( 42) = 47.0
              RMNODE ( 43) = 49.4
114  CONTINUE
```

```
C***********************************************************************
C                                INITIALIZE VARIABLES
C***********************************************************************

      ICYC   = 0
      ITAS   = 0
      MTABL  = 1
      NPA    = 1
      NS1    = 1
      NS2    = 1
      MO     = 0
      NTAG   = 0
      TSRISE = 0
      TSSET  = 0
      CSAT   = 0
      CTIME  = STIME
      DELTQ1 = DELT * FLOAT(NODYN) / 3600.
      DELTQ  = DELT * FLOAT(NODYN)
      NTEMP  = NSTOP - NODYN
        DO 116 N=1,NC
          IF (NJUNC(N,1).LE.NJUNC(N,2)) GO TO 116
          KEEP = NJUNC(N,1)
          NJUNC(N,1) = NJUNC(N,2)
          NJUNC(N,2) = KEEP
  116   CONTINUE
        DO 120 J=1,NJ
          QINWQ(J)  = 0.
          DMASSP(J) = 0.
          NPRL(J)   = 0
          NNRL(J)   = 0
          DOLT4(J)  = 0
          DO4TO5(J) = 0
          DOGT5(J)  = 0
          DOMIN(J)  = 20.
          DOMAX(J)  = 0.
          MINCYC(J) = 0
          MAXCYC(J) = 0
          DOAVG(J)  = 0.
            DO 118 K=1,NUMCON
              CWLOAD(J,K) = 0.
              CONCW(J,K)  = 0.
              C(J,K)      = 0.
  118       CONTINUE
  120   CONTINUE

C*****************   SET PARAMETERS FOR SLACK-WATER TABLES   *****************

      IF (NSWTAB.EQ.0) GO TO 123
       I=1
         DO 122 M=1,NSWTAB
           CALL SWTABL(I,M)
           IF(M.EQ.NSWTAB) GO TO 122
           I=I+1
  122    CONTINUE
  123 CONTINUE

C***********************************************************************
C                           READ QUALITY COEFFICIENTS
C***********************************************************************
```

```
      READ (5,508) HEADER
      READ (5,504) PERCP, CHLNIT, CHLPHO, CHLCAR
      CARCHL = 1./CHLCAR
      PHOCHL = 1./CHLPHO
      NITCHL = 1./CHLNIT
         DO 126 K=1,NUMCON
           NA = 2*K-1
           NB = 2*K
           READ (5,512) BACKC(K),THETA(K), CLIMIT(K), (CNAME(N),N=NA,NB)
  126    CONTINUE
      IF (NUMCON.LT.6) GO TO 143

C*********************************************************************
C                       READ DO RELATED COEFFICIENTS
C*********************************************************************

      READ (5,508) HEADER
      READ (5,504) TSRISE, TSSET
       READ (5,500) NO
        DO 132 I=1,NO
          READ (5,514) NF1(I),NL1(I), PHOT(I), RES(I), DEPTH(I), BENT(I)
          N1 = NF1(I)
          N2 = NL1(I)
            DO 130 J=N1,N2
              DEPTHP(J) = DEPTH(I)
               BENTH(J) = BENT(I)
               PHOTO(J) = PHOT(I)
                RESP(J) = RES(I)
  130       CONTINUE
  132   CONTINUE

C                     ***********************************
C                        CHOOSE REAERATION RELATIONSHIP
C                     ***********************************

      READ (5,500) IREOXK
      GO TO (134,136,138,140), IREOXK
C**********************   O'CONNER-DOBBINS   ************************
  134   A = 12.9
        V =  0.5
        X = -1.5
        A = A * THETA(6) ** (TEMP - 20.)
        GO TO 142
C************************   CHURCHILL   ******************************
  136   A = 11.6
        V =  .97
        Y = -5/3
        A = A * THETA(6) ** (TEMP - 20.)
        GO TO 142
C**************************   USGS   ********************************
  138   A = 7.57
        V =  1.0
        X = -4/3
        A = A * THETA(6) ** (TEMP -20.)
        GO TO 142
C*************************   CONSTANT   *****************************
  140   READ (5,502) REOXK
        REOXK = REOXK * THETA(6) ** (TEMP - 20.)
        REOXK = EXP(-REOXK * DTD)
        REOXK = 1.0 - REOXK
```

```
C**************************   COMPUTE DO SATURATION   *************************

  142   CSAT = 14.652 - (.41022 * TEMP)+(.007991 * TEMP * TEMP)
    *                   -(.000077779 * TEMP * TEMP * TEMP)
  143 CONTINUE

C******************************************************************************
C                           PRINT SUMMARY OF CONTROL DATA
C******************************************************************************

      WRITE (6,600) (ALPHA(I), I=1,80), NSTART, NSTOP, HYDCYC, DELT,
     *              NOCYC, NUTCYC, NDOCYC, DELTQ1, NSPEC, TEMP,
     *              NUMCON, TEMP ,STIME, TSRISE, TSSET, CSAT
      WRITE (6,602)
        DO 144 K=1,NUMCON
          NA = 2 * K - 1
          NB = 2 * K
          WRITE (6,603) K, (CNAME(N), N=NA,NB), BACKC(K), THETA(K)
  144   CONTINUE
      WRITE (6,604) CHLNIT, CHLPHO, CHLCAR, PERCO
      IF (IREOXK.EQ.1) WRITE (6,606)
      IF (IREOXK.EQ.2) WRITE (6,607)
      IF (IREOXK.EQ.3) WRITE (6,608)
      IF (IREOXK.EQ.4) WRITE (6,609)
      IF (KREAC.EQ.1)  WRITE (6,610)
      IF (KREAC.EQ.2)  WRITE (6,611)
      IF (KREAC.EQ.3)  WRITE (6,612)
      IF (MIX.EQ.1)    WRITE (6,614)
      IF (MIX.EQ.2)    WRITE (6,615)
      IF (MIX.EQ.3)    WRITE (6,616)
      IF (MIX.EQ.4)    WRITE (6,617)
      IF (MIX.EQ.5)    WRITE (6,618)
      IF (KDCOP.EQ.1)  WRITE (6,620)
      IF (KDCOP.EQ.2)  WRITE (6,621)

C******************************************************************************
C                              COMPUTE DIFFUSION CONSTANTS
C******************************************************************************

      READ (5,508) HEADER
      READ (5,500) NK
        DO 146 I=1,NK
          READ (5,514) NFC(I), NLC(I), CDIFFK(I)
          N1 = NFC(I)
          N2 = NLC(I)
          DO 145 N=N1,N2
              DIFFK(N) = CDIFFK(I) * DELTQ / CLEN(N)
  145     CONTINUE
  146   CONTINUE

C******************************************************************************
C                         PRINT NETWORK AND HYDRAULIC PARAMETERS
C******************************************************************************

      N1 = NJ
      N2 = NC
      WRITE (6,630) (N, CLEN(N), B(N), AREA(N), CN(N), DIFFK(N),
     *              QNET(N), R(N), (NJUNC(N,K), K=1,2), N, QIN(N),
     *              Y(N), (NCHAN(N,I), I=1,5), N=1,N1)
```

```
      N1 = N1 + 1
      WRITE (6,632) (N, CLEN(N), B(N), AREA(N), CN(N), DIFFK(N),
     *                   QNET(N), R(N), (NJUNC(N,K), K=1,2), N=N1,N2)
      WRITE (6,622)
      DO 147 I=1,NK
        WRITE (6,623) NFC(I), NLC(I), CDIFFK(I)
  147 CONTINUE

C*******************************************************************************
C                     NUTRIENT UPTAKE & REGENERATION RATES
C*******************************************************************************

      READ (5,508) HEADER
      READ (5,500) NR
        DO 149 I=1,NR
          READ (5,514) NF2(I), NL2(I), AMUPP(I), PHUPP(I), REGENN(I),
     *                      REGEPP(I), REBODD(I)
          N1 = NF2(I)
          N2 = NL2(I)
            DO 148 J=N1,N2
              REBOD(J) = REBODD(I)
              REGEP(J) = REGEPP(I)
              REGEN(J) = REGENN(I)
               PHUP(J) = PHUPP(I)
               AMUP(J) = AMUPP(I)
  148       CONTINUE
  149   CONTINUE

C*******************************************************************************
C                         READ CONSTITUENT DECAY RATES
C*******************************************************************************

      READ (5,508) HEADER
      READ (5,500) ND
        DO 154 I=1,ND
          READ (5,514) NF3(I), NL3(I), (DECAYK(I,K), K=1,NUMCON)
          N1 = NF3(I)
          N2 = NL3(I)
            DO 152 J=N1,N2
              DO 150 K=1,NUMCON
                DECAY(J,K) = DECAYK(I,K)
  150         CONTINUE
  152       CONTINUE
  154   CONTINUE

C*******************************************************************************
C                  PRINT JUNCTION RATES AND COEFFICIENTS
C*******************************************************************************

      WRITE (6,624)
      DO 155 I=1,NO
        WRITE (6,625) NF1(I),NL1(I), PHOT(I), RES(I), DEPTH(I), BENT(I)
  155 CONTINUE
      WRITE (6,626)
      DO 156 I=1,NR
        WRITE (6,627) NF2(I), NL2(I), AMUPP(I), PHUP(I), REGENN(I),
     *                    REGEPP(I), REBODO(I)
  156 CONTINUE
      WRITE (6,628)
      DO 157 I=1,ND
      WRITE (6,628) NF3(I), NL3(I), (DECAYK(I,K), K=1,NUMCON)
  157 CONTINUE
      WRITE (6,637)

C**********************************************************************
C                              RATE TRANSFORMATIONS
C**********************************************************************

      DTD = DELT01 / 24.
      DO 160 J=1,NJ
        OREBOD(J) = 1.0 - EXP(-REBOD(J) * DTD)
        ORESEP(J) = 1.0 - EXP(-REGEP(J) * DTD)
        ORESEN(J) = 1.0 - EXP(-REGEN(J) * DTD)
         OPHUP(J) = 1.0 - EXP( -PHUP(J) * DTD)
         OAMUP(J) = 1.0 - EXP( -AMUP(J) * DTD)
          DO 158 K=1,NUMCON
            DECAY(J,K) = DECAY(J,K) * THETA(K) ** (TEMP - 20.)
            IF (K.EQ.3) DECAY(J,3) = DECAY(J,3) * DTD
            ODECAY(J,K) = 1.0 - EXP(-DECAY(J,K) * DTD)
  158     CONTINUE
  160 CONTINUE

C**********************************************************************
C                              WASTEWATER INPUTS
C**********************************************************************

      READ (5,508) HEADER
      READ (5,500) NWASTC, NWASTV, NBANK

C***************************   CONSTANT INPUTS   *************************

      IF (NWASTC.EQ.0) GO TO 178
      READ (5,508) HEADER
      DO 174 I=1,NWASTC
        READ (5,516) JRCW(I), QCW(I), (CWC(I,K), K=1,NUMCON)
        J = JRCW(I)
        IF (I.GT.1) GO TO 166
  162   QINWQ(J) = QCW(I)
          DO 164 K=1,NUMCON
            XLOAD(I,K)  = -QCW(I) * CWC(I,K) * 5.394
            CWLOAD(J,K) = XLOAD(I,K)
  164     CONTINUE
        GO TO 170
  166   IF (JRCW(I).NE.JRCW(I-1)) GO TO 162
        QINWQ(J) = QINWQ(J) + QCW(I)
          DO 168 K=1,NUMCON
            XLOAD(I,K)  = -QCW(I) * CWC(I,K) * 5.394
            CWLOAD(J,K) = CWLOAD(J,K) + XLOAD(I,K)
  168     CONTINUE
  170     DO 172 K=1,NUMCON
            CONCW(J,K) = CWLOAD(J,K) / (-QINWQ(J) * 5.394)
  172     CONTINUE
  174 CONTINUE
  176 CONTINUE

C***********************   WRITE CONSTANT INPUT TABLE   ***********************

      WRITE (6,638)
      DO 178 J=1,NJ
        IF (QINWQ(J).EQ.0) GO TO 178
        WRITE (6,640) J, QINWQ(J), (CONCW(J,K), CWLOAD(J,K), K=1,NUMCON)
  178 CONTINUE

C****************************   VARIABLE INPUTS   ******************************

      IF (NVASTV.EQ.0) GO TO 188
      READ (5,508) HEADER
      WRITE (6,642)
      DO 186 I=1,NVASTV
        READ (5,500) JRVW(I), NINC(I)
        J = JRVW(I)
        NNN = NINC(I)
        KCYC(I) = 0
        KINC(I) = 1
          DO 184 N=1,NNN
            READ (5,516) INCDUR(I,N), FLO(I,N), (CON(K,I,N), K=1,NUMCON)
              DO 180 K=1,NUMCON
                VWLOAD(K) = -FLO(I,N) * CON(K,I,N) * 5.394
  180         CONTINUE

C************************   WRITE VARIABLE INPUT TABLE   ************************

            IF (N.GE.2) GO TO 182
            WRITE (6,644)
            WRITE (6,646) JRVW(I), I, N, INCDUR(I,N), FLO(I,N),
     *                    (CON(K,I,N), VWLOAD(K), K=1,NUMCON)
            GO TO 184
  182       WRITE (6,648)             N, INCDUR(I,N), FLO(I,N),
     *                    (CON(K,I,N), VWLOAD(K), K=1,NUMCON)
  184     CONTINUE
  186 CONTINUE
  188 CONTINUE

C***************************   VARIABLE BANK INPUTS   ***************************
      IF (NBANK.EQ.0) GO TO 196
      READ (5,508) HEADER
      READ (5,506) (SLINE(J), J=1,NJ)
      WRITE(6,650)
      DO 194 I=1,NBANK
        WRITE (6,653)
        READ (5,500) JRBL1(I), JRBL2(I), ICYC1(I), ICYC2(I)
        READ (5,504) BFLOW, (BCON(I,K), K=1,NUMCON)
        J1 = JRBL1(I)
        J2 = JRBL2(I)
          DO 192 J=J1,J2
            TBFLOW(I,J) = BFLOW * SLINE(J)
              DO 190 K=1,NUMCON
                VBLOAD(K) = -TBFLOW(I,J) * BCON(I,K) * 5.394
  190         CONTINUE

C**************************   WRITE BANK INPUT TABLE   **************************

            WRITE (6,652) J, SLINE(J), TBFLOW(I,J), ICYC1(I), ICYC2(I),
     *                    (BCON(I,K), VBLOAD(K), K=1,NUMCON)
  192     CONTINUE
  194 CONTINUE
  196 CONTINUE
```

```
C***********************************************************************
C                            UPPER BOUNDARY CONDITIONS
C***********************************************************************

      READ (5,508) HEADER
      WRITE (6,654)
      I = NWASTV + 1
      JRWW(I) = 114
      READ (5,500) NINC(I)
      NN = NINC(I)
      KCYC(I) = 0
      KINC(I) = 1
      DO 200 N=1,NN
        READ (5,516) INCDUP(I,N), FLO(I,N), (CON(K,I,N), K=1,NUMCON)
          DO 198 K=1,NUMCON
            WWLOAD(K) = -FLO(I,N) * CON(K,I,N) * 5.394
  198     CONTINUE

C**********************   WRITE UPPER BOUNDARY TABLE   **********************

        WRITE (6,656) N, INCDUP(I,N), FLO(I,N),
     *                (CON(K,I,N), WWLOAD(K), K=1,NUMCON)
  200 CONTINUE

C***********************************************************************
C                               INITIAL CONDITIONS
C***********************************************************************

      READ (5,508) HEADER
      WRITE (6,658)
      DO 206 I=1,NJ
        READ (5,514) JINT1, JINT2, (CINT(K), K=1,NUMCON)
        WRITE (6,660) JINT1, JINT2, (CINT(K), K=1,NUMCON)
          DO 204 J=JINT1,JINT2
            DO 202 K=1,NUMCON
              C(J,K) = CINT(K)
  202       CONTINUE
  204     CONTINUE
        IF (JINT2.EQ.NJ) GO TO 208
  206 CONTINUE
  208 CONTINUE

C***********************************************************************
C                            SEAWARD BOUNDARY CONDITIONS
C***********************************************************************

      READ (5,508) HEADER
      READ (5,500) (SEACON(K), K=1,NUMCON)
      DO 214 K=1,NUMCON
        IF (SEACON(K).EQ.1) READ (5,506) CIN(K,1)
        IF (SEACON(K).EQ.2) READ (5,506) (CIN(K,I), I=1,NSPEC)
        IF (SEACON(K).EQ.2) GO TO 214
          DO 212 I=2,NSPEC
            CIN(K,I) = CIN(K,1)
  212     CONTINUE
  214 CONTINUE

C**********************   WRITE SEAWARD BOUNDARY TABLE   **********************

        WRITE (6,662)
      DO 216 I=1,NSPEC
        WRITE (6,664) I, (CIN(K,I), K=1,NUMCON)
  216 CONTINUE

C*******************************************************************************
C                        INITIALIZE VOLUMES AND MASSES
C*******************************************************************************
C
C*******************   CALCULATE MEAN JUNCTION VOLUMES   ***********************

      DO 222 J=1,NJ
        AVOL(J) = 0.
          SASUM = 0.
         VOLSUM = 0.
          DO 218 K=1,5
            IF (NCHAN(J,K).EQ.0) GO TO 220
            N = NCHAN(J,K)
            SAREA  = CLEN(N) * B(N)
            SASUM  = SASUM + SAREA
            VOLSUM = VOLSUM + SAREA * R(N)
  218     CONTINUE
  220   AVGD    = VOLSUM / SASUM
        AVOL(J) = ASUR(J) * AVGD
  222 CONTINUE

C************   CORRECT VOLUMES FOR INITIAL STARTING CONDITIONS   **************

  224 READ (3) ICYCTF, (YNEW(J), J=1,NJ)
      IF (ICYCTF.GE.HYDCYC) GO TO 226
        READ (3) (Q(N), V(N), N=1,NC)
        GO TO 224
  226 DO 228 N=1,NC
        NL = NJUNC(N,1)
        NH = NJUNC(N,2)
        R(N) = R(N) + (YNEW(NH) - Y(NH) + YNEW(NL) - Y(NL)) * .5
  228 CONTINUE
      DO 230 J=1,NJ
        VOL(J) = AVOL(J) + ASUR(J) * (YNEW(J) - Y(J))
        Y(J)   = YNEW(J)
  230 CONTINUE

C*************************   CALCULATE INITIAL MASS   **************************

      DO 234 K=1,NUMCON
        DO 232 J=1,NJ
          CMASS(J,K) = C(J,K) * VOL(J)
  232   CONTINUE
  234 CONTINUE

C**********   COMPUTE INFLOW/OUTFLOW VOLUMES AND WASTEWATER MASSES   ***********

      DO 240 J=1,NJ
        VOLQIN(J) = QINWQ(J) * DELTQ
          DO 238 K=1,NUMCON
            CWLOAD(J,K) = CWLOAD(J,K) * DELTQ / 5.394
  238     CONTINUE
  240 CONTINUE
      JJ = NWASTW + 1
      DO 244 I=1,JJ
        NNN = NINC(I)
```

```
         DO 242 N=1,NNN
           FLO(I,N) = FLO(I,N) * DELTO
  242    CONTINUE
  244 CONTINUE
      IF (NBANK.EQ.0) GO TO 250
      DO 248 I=1,NBANK
       J1 = JRBL1(I)
       J2 = JRBL2(I)
         DO 246 J=J1,J2
           TBFLOW(I,J) = TBFLOW(I,J) * DELTO
  246    CONTINUE
  248 CONTINUE
  250 CONTINUE

C***********************************************************************
C                            MAIN QUALITY LOOP
C***********************************************************************

      DO 366 ICYC=1,NQCYC
       CTIME = CTIME + DELTQ1
       IF (CTIME.GT.24) CTIME = CTIME - 24.

C************************  READ SYSTEM CONDITIONS  ************************

       READ (3) (Q(N), V(N), N=1,NC)
       IF (ICYCTF.GE.NTEMP) GO TO 252
         READ (3) ICYCTF, (YNEW(J), J=1,NJ)
         GO TO 254
  252  REWIND 3
       READ (3) ICYCTF, (YNEW(J), J=1,NJ)
  254  CONTINUE

C                       **************************
C*************************  ADVECTION + DIFFUSION  *************************
C                       **************************

       CALL MIXER (MIX)

C                       **************************
C*************************  DECAY + MASS TRANSFER  *************************
C                       **************************

         DO 302 J=2,NJ
           DO 300 K=1,NUMCON
             GO TO (264,266,268,270,280,282), K

C*****************************   CONSTITUENT 1   *****************************

  264          IF (KREAC.EQ.2) GO TO 300
                XMASSN = C(J,1) * VOL(J) * ODECAY(J,1)
                XMNH3  = 4.57 * XMASSN
                XMASSU = C(J,1) * VOL(J) * OAMUP(J)
                CMASS(J,1) = CMASS(J,1) - XMASSN
                GO TO 300

C*****************************   CONSTITUENT 2   *****************************

  266          IF (KREAC.EQ.2) GO TO 300
                YMASSU = C(J,2) * VOL(J) * ODECAY(J,2)
                CMASS(J,2) = CMASS(J,2) + XMASSN
```

```
              GO TO 300

C******************************   CONSTITUENT 3   ******************************

  268        IF (KPEAC.EQ.1) GO TO 300
               ZMASSD = (DECAY(J,3) * C(J,3) * C(J,3) * VOL(J))/
     *                 ((DECAY(J,3) * C(J,3)) + 1 )
               ZMASSU = C(J,3) * VOL(J) * OPHUP(J)
               CMASS(J,3) = CMASS(J,3) - ZMASSD
               GO TO 300

C******************************   CONSTITUENT 4   ******************************

  270        IF (KPEAC.EQ.4) GO TO 300
               DMASSX    = C(J,4) * VOL(J) * ODECAY(J,4)
               DMASSD(J) = DMASSD(J) + DMASSX * PFPCD
               RMASSN    = DMASSD(J) * NITCHL * OREGEN(J)
               RMASSP    = DMASSD(J) * PHOCHL * OREGEP(J)
               RMASSC    = DMASSD(J) * CARCHL * OREBOD(J)
               DMASSD(J) = DMASSD(J) - RMASSN - RMASSP - RMASSC
               GO TO (272,274,276), KPEAC
C            ****************  NITROGEN UPTAKE ONLY  ****************
  272          MCHLON = (XMASSU + YMASSU) * CHLNIT
               CMASS(J,4) = CMASS(J,4) + MCHLON - DMASSX
               CMASS(J,1) = CMASS(J,1) + RMASSN - XMASSU
               CMASS(J,2) = CMASS(J,2) - YMASSU
               GO TO 300
C            *****************  PHOSPHORUS UPTAKE ONLY  *************
  274          MCHLOP = ZMASSU * CHLPHO
               CMASS(J,4) = CMASS(J,4) + MCHLOP - DMASSX
               CMASS(J,3) = CMASS(J,3) + RMASSP - ZMASSU
               GO TO 300
C            *************  NITROGEN & PHOSPHORUS UPTAKE  ***********
  276          MCHLON = (XMASSU + YMASSU) * CHLNIT
               MCHLOP = ZMASSU * CHLPHO
               IF (MCHLON.LE.MCHLOP) GO TO 278
C            *******************  PHOSPHORUS LIMITS  ****************
                 CMASS(J,4) = CMASS(J,4) + MCHLOP - DMASSX
                 CMASS(J,3) = CMASS(J,3) + RMASSP - ZMASSU
                 CMASS(J,1) = CMASS(J,1) + RMASSN
     *                      - XMASSU * (MCHLOP/MCHLON)
                 CMASS(J,2) = CMASS(J,2) - YMASSU * (MCHLOP/MCHLON)
                 IF (ICYC.LT.NUTCYC) GO TO 300
                   NPRL(J) = NPRL(J) + 1
                   GO TO 300
C            ********************  NITROGEN LIMITS  *****************
  278            CMASS(J,4) = CMASS(J,4) + MCHLON - DMASSX
                 CMASS(J,1) = CMASS(J,1) + RMASSN - XMASSU
                 CMASS(J,3) = CMASS(J,3) + RMASSP
     *                      - ZMASSU * (MCHLON/MCHLOP)
                 CMASS(J,2) = CMASS(J,2) - YMASSU
                 IF (ICYC.LT.NUTCYC) GO TO 300
                   NNRL(J) = NNRL(J) + 1
               GO TO 300

C******************************   CONSTITUENT 5   ******************************

  280        XMBOD = C(J,5) * VOL(J) * ODECAY(J,5)
             CMASS(J,5) = CMASS(J,5) - XMBOD + RMASSC
             GO TO 300
```

```
C*******************************   CONSTITUENT 6   ******************************
C
C                   **********  RESPIRATION  **********
  282         RESPM = VOL(J) * RESP(J) * DELTQ1 * C(J,4)
C                   ********  PHOTOSYNTHESIS  *********
              IF (CTIME.GT.TSRISE.AND.CTIME.LE.TSSET) GO TO 284
                GO TO 298
  284         XVOL = ASUR(J) * DEPTHP(J)
              IF (XVOL.GT.VOL(J)) GO TO 286
                PHOTOM = XVOL * PHOTO(J) * C(J,4) * DELTQ1
                GO TO 290
  286         PHOTOM = VOL(J) * PHOTO(J) * C(J,4) * DELTQ1
              GO TO 290
  288         PHOTOM = 0.
C                   ********  BENTHIC DEMAND  ********
  290         BENTHM = ASUR(J) * BENTH(J) * 3.28166677 * DTD
              IF (IREOXK.EQ.4) GO TO 298
C                   **********  REAERATION  **********
                ILARGE = NCHAN(J,1)
                DO 292 M=2,5
                  IF(NCHAN(J,M).EQ.0) GO TO 294
                  QA = ABS(Q(ILARGE))
                  QB = ABS(Q(NCHAN(J,M)))
                  IF(QA.LT.QB) ILARGE = NCHAN(J,M)
  292           CONTINUE
  294         N = ILARGE
  296         CONTINUE
              REOXK = A * ABS(V(N))**W * R(N)**X
              REOXK = 1.0 - EXP(-REOXK * DTD)
  298         CONTINUE
              REMASS = VOL(J) * (CSAT - C(J,6)) * REOXK
              CMASS(J,6) = CMASS(J,6) + PHOTOM - BENTHM - RESPM
     *                      + REMASS - XMBOD - XMNH3
  300       CONTINUE
  302     CONTINUE

C*************************   ADD CONSTANT WASTE LOADS   *************************

          IF (NWASTC.EQ.0) GO TO 312
          DO 312 J=2,NJ
            IF (VOLDIN(J)) 304,312,308
  304         DO 306 K=1,NUMCOM
                CMASS(J,K) = CMASS(J,K) + CWLOAD(J,K)
  306         CONTINUE
              GO TO 312
  308         DO 310 K=1,NUMCOM
                CMASS(J,K) = CMASS(J,K) - C(J,K) * VOLOIN(J)
  310         CONTINUE
  312     CONTINUE

C**************   ADD VARIABLE WASTE AND UPPER BOUNDARY LOADS   ****************

          JJ = NWASTV + 1
          DO 318 I=1,JJ
            J = JRVW(I)
            N = KINC(I)
            KCYC(I) = KCYC(I) + 1
            IF (KCYC(I).LE.INCDUR(I,N)) GO TO 314
            KCYC(I) = 1
            KINC(I) = KINC(I) + 1
            N = KINC(I)
            IF (N.LE.NINC(I)) GO TO 314
            KINC(I) = 1
            N = KINC(I)
  314         DO 316 K=1,NUMCON
                CMASS(J,K) = CMASS(J,K) - FLO(I,N) * CON(K,I,N)
  316         CONTINUE
  318     CONTINUE
C************************   ADD VARIABLE BANK LOADS   ****************************
          IF (NBANK.EQ.0) GO TO 326
          DO 324 I=1,NBANK
            IF (ICYC.LT.ICYC1(J).OR.ICYC.GT.ICYC2(I)) GO TO 324
            J1 = JRBL1(I)
            J2 = JRBL2(I)
              DO 322 J=J1,J2
                DO 320 K=1,NUMCON
                  CMASS(J,K) = CMASS(J,K) - TBFLOW(I,J) * BCON(I,K)
  320           CONTINUE
  322         CONTINUE
  324     CONTINUE
  326     CONTINUE
C*********   CORRECT JUNCTION VOLUMES AND COMPUTE NEW CONCENTRATIONS   *********
          NTAG = NTAG + 1
          IF (NTAG.EQ.NSPEC) NTAG = 0
          DO 328 K=1,NUMCON
            C(1,K)= CIN(K,NTAG+1)
  328     CONTINUE
          DO 332 J=2,NJ
            VOL(J) = VOL(J) + ASUR(J) * (YNEW(J) - Y(J))
              DO 330 K=1,NUMCON
                C(J,K) = CMASS(J,K) / VOL(J)
  330         CONTINUE
  332     CONTINUE
          DO 334 N=1,NC
            NL = NJUNC(N,1)
            NH = NJUNC(N,2)
            R(N) = R(N) + (YNEW(NH) - Y(NH) + YNEW(NL) - Y(NL)) * .5
  334     CONTINUE
C*********************   PREVENT NEGATIVE CONCENTRATIONS   *********************
          DO 338 J=1,NJ
            Y(J) = YNEW(J)
              DO 336 K=1,NUMCON
                IF (C(J,K).GE.BACKC(K)) GO TO 336
                IF (KDCOP.EQ.1) WRITE (6,666) J, ICYC,K, C(J,K)
                C(J,K) = BACKC(K)
                CMASS(J,K) = C(J,K) * VOL(J)
  336         CONTINUE
  338     CONTINUE
C***********   CHECK CONCENTRATIONS AGAINST SPECIFIED LIMITS   ****************
          DO 342 J=1,NJ
            DO 340 K=1,NUMCON
```

```
              IF (C(J,K).LE.CLIMIT(K)) GO TO 340
                WRITE (6,669) K, CLIMIT(K), J, ICYC
                WRITE (5,670) ((C(L,M), M=1,NUMCON), L=1,NJ)
                STOP
  340         CONTINUE
  342       CONTINUE

C*******************   COMPUTE RANGES OF CONSTITUENT 6   *********************

            IF (ICYC.LT.MDOCYC) GO TO 350
            IF (NUMCON.LT.6) GO TO 350
              DO 348 J=1,NJ
                IF (C(J,6).LT.4)             DOLT4(J)  = DOLT4(J) + 1
                IF (C(J,6).GT.5)             DOGT5(J)  = DOGT5(J) + 1
                IF (C(J,6).GE.4.AND.C(J,6).LE.5) DO4TO5(J) = DO4TO5(J) + 1
                IF (C(J,6).GT.DOMIN(J)) GO TO 344
                  DOMIN(J)  = C(J,6)
                  MINCYC(J) = ICYC
                  GO TO  346
  344           IF (C(J,6).LT.DOMAX(J)) GO TO 346
                  DOMAX(J)  = C(J,6)
                  MAXCYC(J) = ICYC
  346         CONTINUE
                DOAVG(J) = DOAVG(J) + C(J,6)
  348         CONTINUE
  350       CONTINUE

C**************************   READ OBSERVED DATA   ****************************

            IF (NDATA.EQ.0) GO TO 354
            IF (NDA.GT.NOBDAT) GO TO 354
            IF (ICYC.NE.NOBCYC(NDA)) GO TO 354
              READ (5,508) HEADER
              DO 352 K=1,NDATA
                READ (5,510) ((OBDATA(I,J,K), I=1,3), J=1,6), RMDATA(K)
  352         CONTINUE
              NDA = NDA + 1
  354       CONTINUE

C******************   STORE CONCENTRATIONS FOR TIME PLOTS   ******************

            IF (NTP.EQ.0) GO TO 358
              DO 356 I=1,NTP
                J = JUNCTP(I)
                WRITE (11) ICYC, (C(J,K), K=1,NUMCON)
  356         CONTINUE
  358       CONTINUE

C*************************   CHECK FOR SUMRY1 OUTPUT   ************************

            IF (NS1.GT.NSUM1) GO TO 360
            IF (ICYC.LT.IPRT1(NS1)) GO TO 360
              IP1  = IPRT1(NS1)
              LP1  = LPRT1(NS1)
              IPL1 = IPLT1(NS1)
            CALL SUMARY(IP1,LP1,IPL1,1)
            IF (ICYC.EQ.LPRT1(NS1)) NS1 = NS1 + 1
  360       CONTINUE

C************************   CHECK FOR SUMRY2 OUTPUT   *************************
```

```
          IF (NS2.GT.NSUM2) GO TO 362
          IF (ICYC.LT.IPRT2(NS2)) GO TO 362
            IP2  = IPRT2(NS2)
            LP2  = LPRT2(NS2)
            IPL2 = IPLT2(NS2)
          CALL SUMAPY(IP2,LP2,IPL2,2)
          IF (ICYC.EQ.LPRT2(NS2)) NS2 = NS2 + 1
  362     CONTINUE

C**********************   CHECK FOR SLACKWATER OUTPUT   ***********************

          IF (NSWTAB.EQ.0) GO TO 366
            IF (ICYC.LT.NFPC(MTAEL).OR.ICYC.GT.NLPC(MTABL)) GO TO 366
            ITAB = ITAB + 1
            CALL SWTABL(ITAB,MTABL)
            IF (ICYC.NE.NLPC(MTABL)) GO TO 364
            IF (MTABL.EQ.NSWTAB) GO TO 364
            MTABL = MTABL + 1
  364     CONTINUE
  366 CONTINUE

C*************************   EXIT MAIN QUALITY LOOP   *************************

      IF (NUMCON.LT.6) GO TO 370

C**************************   PRINT D.O. SUMMARY   ****************************

        WRITE (6,672) NDOCYC
          DO 368 J=1,NJ
            DOAVG(J) = DOAVG(J) / FLOAT(NQCYC-NDOCYC+1)
            WRITE (6,674) J, DOMIN(J), MINCYC(J), DOMAX(J), MAXCYC(J),
     *                    DOAVG(J), DOLT4(J), DO4TO5(J), DOGT5(J)
  368     CONTINUE
  370 CONTINUE
      IF (KREAC.NE.3) GO TO 374

C*******************   PRINT NUTRIENT LIMITATION SUMMARY   ********************

      WRITE (6,676) NUTCYC
        L=NJ/3
        DO 372 J=1,L
          JJ=J+(NJ/3)
          JK=J+(2*NJ/3)
          WRITE (6,678) J, NNRL(J), NPRL(J), JJ, NNRL(JJ), NPRL(JJ),
     *                  JK, NNRL(JK), NPRL(JK)
  372   CONTINUE
        I=JK+1
        DO 373 J=I,NJ
          WRITE (6,679) J, NNRL(J), NPRL(J)
  373   CONTINUE
  374 CONTINUE
      WRITE (6,680) ICYC, ICYCTF
      IF (NTP.GT.0) CALL TPLOT

C******************************************************************************
C                                 FORMAT STATEMENTS
C******************************************************************************

500   FORMAT (16I5)
```

```
502   FORMAT (8I10)
504   FORMAT (8F10.0)
506   FORMAT (16F5.0)
508   FORMAT (20A4)
510   FORMAT (18F4.0,F8.0)
512   FORMAT (7F10.0,2A4)
514   FORMAT (2I10,6F10.0)
516   FORMAT (I10,7F10.0)
600   FORMAT (1H1/1X,20A4,16X,'ENVIRONMENTAL PROTECTION AGENCY',/1X,20A4
     *,21X,'DYNAMIC ESTUARY MODEL',/1X,20A4/1X,20A4,///3X,24(1H*),'   HY
     *DRAULIC CONTROL DATA   ',24(1H*),//,3X,'FIRST CYCLE ON    LAST CYC
     *LE ON    BEGIN READING TAPE       HYDRAULIC',/,3X,'HYDRAULIC TAPE
     *   HYDRAULIC TAPE          AT CYCLE          TIME STEP (SEC.)',/,6X,
     *'(NSTART)',10X,'(NSTOP)',13X,'(HYDCYC)',14X,'(DELT)',//8X,I4,14X,I
     *4,16X,I4,16X,F6.2,///,3X,45(1H*),'   QUALITY CONTROL DATA   ',45(1
     *H*),//,13X,'NUMBER OF          NUTRIENT LIMITATION',7X,'D.O. SUMMAR
     *Y',10X,'QUALITY',11X,'QUALITY STEPS',/,11X,'QUALITY CYCLES    SUMM
     *ARY BEGINS AT CYCLE    BEGINS AT CYCLE    TIME STEP (HRS)     PER
     *TIDAL PERIOD',/,14X,'(NQCYC)',15X,'(NUTCYC)',15X,'(NDOCYC)',12X,'(
     *DELT21)',13X,'(NSPEC)',//,15X,I4,19X,I4,19X,I4,14X,F6.2,15X,I4,///
     *                                                     ,6X,'NUMBER OF',21
     *X,'STARTING TIME    TIME OF      TIME OF     D.O. SATURATION',/,3X,'
     *CONSTITUENTS    TEMPERATURE    FOR THIS RUN     SUNRISE      SUNSET
     *      AT ',F5.2,'  C',/,5X,'(NUMCON)',9X,'(TEMP)',9X,'(STIME)',7X,
     *'(TSRISE)    (TSSET)',9X,'(CSAT)',//,5X,I4,12X,F6.2,11X,F5.2,9X,F5
     *.2,7X,F5.2,8X,F6.3,////)
602   FORMAT (1H ,  3X,'CONSTITUENT    CONSTITUENT     BACKGROUND
     *  TEMPERATURE',/,7X,'NUMBER             NAME        CONCENTRATION
     *CORRECTION FACTOR',/,22X,'(CNAME)',6X,'(BACKC)',12X,'(THETA)',/  )
603   FORMAT (1H ,8X,I2,10X,2A4,9X,F6.3,13X,F5.3 )
604   FORMAT (1H0,74X,'PERCENT OF DECAYED ALGAE',/,7X,'CHLOROPHYLL/NITRO
     *GEN    CHLOROPHYLL/PHOSPHOROUS    CHLOROPHYLL/CARBON    WHICH IS BI
     *O-DEGRADABLE',/,8X,'(CHLNIT)',17X,'(CHLPHO)',16X,'(CHLCAR)',18X,'(
     *PERCD)',//,10X,F6.2,19X,F6.2,16X,F6.2,21X,F6.2,// )
606   FORMAT (1H ,  3X,'THE REOXYGENATION CONSTANT FOR D.O. IS COMPUTED
     *USING THE O-CONNOR-DOBBINS EQUATION : K2 = 12.9 * V**.5 / H**1.5')
607   FORMAT (1H ,  3X,'THE REOXYGENATION CONSTANT FOR D.O. IS COMPUTED
     *USING THE CHURCHILL EQUATION : K2 = 11.6 * V**.97 / H**1.67 ' )
608   FORMAT (1H ,  3X,'THE REOXYGENATION CONSTANT FOR D.O. IS COMPUTED
     *USING THE USGS EQUATION : K2 = 7.57 * V / H**1.33 ' )
609   FORMAT (1H ,  3X,'THE REOXYGENATION CONSTANT FOR D.O. IS CONSTANT
     *AND IS EQUAL TO ',F7.3 )
610   FORMAT (1H ,  3X,'ONLY NITROGEN UPTAKE BY ALGAE IS CONSIDERED  (KR
     *EAC = 1)  ' )
611   FORMAT (1H ,  3X,'ONLY PHOSPHOROUS UPTAKE BY ALGAE IS CONSIDERED (
     *KREAC = 2) ' )
612   FORMAT (1H ,  3X,'NITROGEN AND PHOSPHOROUS UPTAKE BY ALGAE IS CONS
     *IDERED  (KREAC = 3) '  )
614   FORMAT (1H ,  3X,'CONSTITUENT CONCENTRATIONS IN ADVECTED WATER ARE
     * EQUAL TO THE UPSTREAM CONCENTRATION  (MIX=1) ' )
615   FORMAT (1H ,  3X,'CONSTITUENT CONCENTRATIONS IN ADVECTED WATER ARE
     * COMPUTED USING THE 1/2 POINT CONCENTRATION  (MIX=2)' )
616   FORMAT (1H ,  3X,'CONSTITUENT CONCENTRATIONS IN ADVECTED WATER ARE
     * COMPUTED USING THE 1/3 POINT CONCENTRATION  (MIX=3)' )
617   FORMAT (1H ,  3X,'CONSTITUENT CONCENTRATIONS IN ADVECTED WATER ARE
     * COMPUTED USING THE 1/4 POINT CONCENTRATION  (MIX=4)' )
618   FORMAT (1H ,  3X,'CONSTITUENT CONCENTRATIONS IN ADVECTED WATER ARE
     * COMPUTED USING THE 2-WAY PROPORTIONAL METHOD (MIX=5)' )
620   FORMAT (1H ,  3X,'DEPLETION CORRECTIONS ARE PRINTED  (KDCOP=1)' )
621   FORMAT (1H ,  3X,'DEPLETION CORRECTIONS NOT PRINTED  (KDCOP=2)' )
```

```
622   FORMAT (1H ,////,40X,15(1H*),'   DIFFUSION CONSTANTS    ',15(1H*),/
     */ ,44X,'CHANNEL    CHANNEL          CONSTANT (C4) ',/,40X,50(1H-),
     */  )
623   FORMAT (1H ,  45X,I4,7X,I4,12X,F6.2)
624   FORMAT (1H1,///,1X,35(1H*),'      SUMMARY OF DISSOLVED OXYGEN (CONS
     *TITUENT 6)  RATES      ',35(1H*),////38X,'   PHOTOSYNTHESIS      RESP
     *IRATION    PHOTIC DEPTH    BENTHIC DEMAND',/,22X,'FROM          TO
     *       (PHOT)',12X,'(RES)',9X,'(DEPTH)',10X,'(BENT)',/22X,'JUNC
     *   JUNC    ',8X,'(MG/HR/UG CHLORO)',14X,'(FEET)',/ ,15X,90(1H-),/)
625   FORMAT (/23X,I3,7X,I3,7X,F7.5,11X,F6.4,12X,F5.2,10X,F6.3)
626   FORMAT (1H1,///,1X,35(1H*),'      SUMMARY OF NUTRIENT UPTAKE AND RE
     *GENERATION RATES      ',35(1H*),////10X,'FROM       TO      CONST 1
     * UPTAKE    CONST 3 UPTAKE      CONST 1 REGEN    CONST 3 REGEN    CO
     *NST 5 REGEN',/,10X,'JUNC       JUNC           (AMUPP)',11X,'(PHUPP)
     *         (REGENN)',9X,'(REGEPP)',9X,'(REBODD)',/ ,5X,110(1H-),/)
627   FORMAT (/10X,I3,7X,I3,10X,F5.3,13X,F5.3,1X,3(12X,F5.3))
628   FORMAT (1H1,///,1X,40(1H*),'      SUMMARY OF CONSTITUENT DECAY RATE
     *S     ',40(1H*),////26X,'    CONST 1         CONST 2        CONST 3 *
     *     CONST 4        CONST 5        CONST 6',/,10X,'FROM       TO
     * (DECAYK 1)    (DECAYK 2)    (DECAYK 3)    (DECAYK 4)    (DECAYK 5
     *)     (DECAYK6)',/,10X,'JUNC',6X, 'JUNC      (PER DAY)      (PER DAY)
     *     (PER DAY)      (PER DAY)      (PER DAY)      (PER DAY)',/ ,5X,11
     *0(1H-),/)
629   FORMAT (/10X,I3,7X,I3,6(9X,F5.3))
630   FORMAT (1H1,// ,5X,45(1H*),'   SUMMARY OF HYDRAULIC INPUTS    ',45(
     *1H*),///,15X,'CROSS-SECTIONAL AREA AND HYDRAULIC RADIUS OF CHANNEL
     *S AND JUNCTION HEADS ARE AT MEAN TIDE',///  ,1X,31(1H*),'  CHANNEL
     * DATA  ',32(1H*),5X,15(1H*),'  JUNCTION DATA  ',14(1H*),//,1X,'CHA
     *N  LENGTH  WIDTH  CS-AREA  MANNING  DIFF  NET FLOW  HYD. RAD.  JUN
     *C. AT ENDS  I  JUNC  INFLOW  HEAD   CHANNELS INTO JUNCTION',/,1X,
     *81(1H-),'I',67(1H-),/  (1X,I3,3X,F6.0,2X,F6.0,2X,F7.0,2X,F5.3,2X,
     *F5.2,2X,F8.2,3X,F5.1,6X,I3,4X,I3,4X,'I',2X,I3,2X,F7.1,2X,F4.2,2X,
     *5I5)    )
632   FORMAT (1X,I3,3X,F6.0,2X,F6.0,2X,F7.0,2X,F5.3,2X,F5.2,2X,F8.2,3X,
     *F5.1,6X,I3,4X,I3,4X,'I' )
636   FORMAT (4X,I3,4X,2(2X,F4.2),1X,3(2X,F5.2),2X,6(3X,F5.3),2X,2(2X,F6
     *.4),2(3X,F5.2))
637   FORMAT (10X,/////,' *  CONSTITUENT 3 UNDERGOES 2ND ORDER DECAY' )
638   FORMAT(1H1//10X,30(1H*),5X,'SUMMARY OF CONSTANT WASTEWATER  LOADS'
     *,5X,30(1H*)////,24X, 'CONSTITUENT 1     CONSTITUENT 2     CONSTITU
     *ENT 3     CONSTITUENT 4     CONSTITUENT 5     CONSTITUENT 6',/,2X,
     *'JUNC.   TOTAL FLOW    CONC.    LOAD      CONC.    LOAD      CONC.
     *  LOAD      CONC.    LOAD      CONC.    LOAD      CONC.     LOAD',/,12
     *X,'(CFS)        (MG/L) (LB/DAY)   (MG/L) (LB/DAY)   (MG/L) (LB/DAY)
     *  (UG/L) (LB/DAY)   (MG/L) (LB/DAY)   (MG/L) (LB/DAY)',/,1X,130(1H
     *-))
640   FORMAT (/2X,I3,6X,F7.1,2X,6(3X,F5.1,1X,F9.0))
642   FORMAT(1H1//10X,30(1H*),5X,'SUMMARY OF VARIABLE WASTEWATER LOADS',
     *5X,30(1H*)//// 17X, 'INCREMENT                  CONSTITUENT 1   CONSTITUE
     *NT 2   CONSTITUENT 3   CONSTITUENT 4   CONSTITUENT 5   CONSTITUENT
     *6',/,1X,'JUNC.  DISCH.  NO.  LENGTH    FLOW    CONC.    LOAD     CONC.
     *    LOAD   CONC.    LOAD   CONC.     LOAD    CONC.     LOAD   CONC.
     *  LOAD',/,20X,'(CYCLES) (CFS)   (MG/L) (LB/DAY) (MG/L) (LB/DAY) (MG
     */L) (LB/DAY) (UG/L) (LB/DAY) (MG/L) (LB/DAY) (MG/L) (LB/DAY)')
644   FORMAT (/1X,130(1H-)/)
646   FORMAT (/1X,I3,5X,I2,5X,I2,3X,I4,1X,F8.1,1X,6(2X,F5.1,1X,F6.0))
648   FORMAT (/16X,I2,4X,I3,3X,F6.0,1X,6(2X,F5.1,1X,F8.0))
650   FORMAT (1H1//20X,30(1H*),5X,'SUMMARY OF BANK LOADS',5X,30(1H*)////
     *6X,'SHORE  BANK    CYCLES     CONSTITUENT 1     CONSTITUENT 2     CON
     *STITUENT 3     CONSTITUENT 4     CONSTITUENT 5     CONSTITUENT 6',/,1
     *Y,'JUNC. LINE  FLOW  START STOP   CONC.   LOAD     CONC.  LOAD
     *  CONC.   LOAD     CONC.   LOAD     CONC.   LOAD      CONC.  LOAD'
     *,/,6X,'(MI)  (CFS)',14X,'(MG/L) (LB/DAY)  (MG/L) (LB/DAY)  (MG/L)
     *(LB/DAY)  (UG/L) (LB/DAY)  (MG/L) (LB/DAY)  (MG/L) (LB/DAY)')
652   FORMAT (1X,I3,2X,F4.1,1X,F6.0,2(2X,I4),6(3X,F5.1,1X,F8.0))
653   FORMAT (1X,/1X,130(1H-),/)
654   FORMAT (1H1//5X,30(1H*),5X,'SUMMARY OF UPPER BOUNDARY CONDITIONS
     *(NODE 114)',5X,30(1H*)////,3X,'INCREMENT',13X,'CONSTITUENT 1     C
     *ONSTITUENT 2      CONSTITUENT 3     CONSTITUENT 4     CONSTITUENT 5
     *      CONSTITUENT 6',/,2X,'NO.  LENGTH    FLOW    CONC.    LOAD
     * CONC.    LOAD     CONC.    LOAD     CONC.    LOAD     CONC.    LO
     *AD     CONC.    LOAD',/,6X,'(CYCLES)  (CFS)   (MG/L)  (LB/DAY)  (M
     *G/L)  (LB/DAY)  (MG/L)  (LB/DAY)  (UG/L)  (LB/DAY)  (MG/L)  (LB/DA
     *Y)  (MG/L)  (LB/DAY)',/,1X,130(1H-)/)
656   FORMAT(/2X,I3,3X,I4,3X,F6.0,3(3X,F5.2,3X,F7.0),2X,F6.2,3X,F7.0,2(3
     *X,F5.2,3X,F7.0))
658   FORMAT (1H1,///,10X,35(1H*),'     SUMMARY OF INITIAL CONCENTRATION
     *S     ',35(1H*),/// ,23X,'FROM      TO       CONST 1      CONST 2
     *  CONST 3      CONST 4      CONST 5      CONST 6',/ ,23X,'JUNC      JU
     *NC       (MG/L)        (MG/L)        (MG/L)        (UG/L)        (MG/L)
     *  (MG/L)',/ ,15X,100(1H-))
660   FORMAT (/23X,I3,6X,I3,6(7X,F5.2))
662   FORMAT (1H1///1X,35(1H*),'   TIDAL CYCLE VARIATION OF SEAWARD BOUN
     *DARY CONDITIONS   ',30(1H*)////45X,'SPECIFIED CONCENTRATIONS AT JU
     *NCTION 1'//11X,'INTERVAL    CONSTITUENT 1    CONSTITUENT 2    CONS
     *TITUENT 3    CONSTITUENT 4    CONSTITUENT 5    CONSTITUENT 6',/,26
     *X,'(MG/L)',11X,'(MG/L)',11X,'(MG/L)',11X,'(UG/L)',11X,'(MG/L)',11X
     *,'(MG/L)',/,1X,130(1H-)/  )
664   FORMAT (14X,I2,10X,F5.2,5(12X,F5.2))
666   FORMAT(39H DEPLETION CORRECTION MADE AT JUNCTION I3,7H CYCLE I4,
     * 21H FOR CONSTITUENT NO. I1,12H. CONC. WAS F10.2)
668   FORMAT(34H0CONCENTRATION OF CONSTITUENT NO. I1,8H EXCEEDS,F7.1,
     * 13H IN JUNCTION I3,14H DURING CYCLE I5,25H.   EXECUTION TERMINATE
     *D.)
670   FORMAT(1H 8E16.8)
672   FORMAT (1H1///20X,20(1H*),3X,'SUMMARY OF DISSOLVED OXYGEN BEYOND C
     *YCLE ',I4,3X,20(1H*)///10X,'JUNCTION       MINIMUM CONC.          MA
     *XIMUM CONC.        AVERAGE CONC.      NO. CYCLES     NO. CYCLES     NO
     *. CYCLES',/,23X,'(MG/L)     CYCLE',6X,'(MG/L)     CYCLE',9X,'(MG/L)'
     *,12X,'DO<4',9X,'4<DO<5',9X,'DO>5',/,10X,112(1H-)/)
674   FORMAT (12X,I3,2(8X,F5.2,5X,I4),10X,F5.2,3X,3(10X,I4)  )
676   FORMAT (1H1///10X,30(1H*),'    SUMMARY OF NUTRIENT LIMITATION BEYON
     *D CYCLE ',I4,3X,30(1H*),////,23X,'NO. OF CYCLES',27X,'NO. OF CYCLE
     *S',27X,'NO. OF CYCLES',/,11X,'JUNC.    N LIMITS   P LIMITS',12X,
     *'JUNC.    N LIMITS   P LIMITS',12X,'JUNC.    N LIMITS   P LIMITS',
     */,8X,114(1H-)/  )
678   FORMAT (4X, 3(7X,I3,8X,I4,7X,I4,7X)  )
679   FORMAT (91X,I3,8X,I4,7X,I4)
680   FORMAT (1H //20X,'NUMBER OF QUALITY CYCLES = ',I5,/,20X,'HYDRAULIC
     * TAPE LAST READ AT CYCLE ',I5 )
      STOP
      END
```

```
C********************************************************************************
C                                         MIXER
C********************************************************************************
      SUBROUTINE MIXER (MIX)
C
C        THIS SUBROUTINE DETERMINES THE CONCENTRATION USED IN THE
C       ADVECTION AND DISPERSION EQUATIONS AND THEN COMPUTES THE
C       MASS OF EACH CONSTITUENT TRANSPORTED BETWEEN JUNCTIONS. THE
C       METHOD USED TO DETERMINE THE CONCENTRATIONS IS DEFINED BY...
C            MIX = 1    USE THE UPSTREAM CONCENTRATION
C                  2    USE THE 1/2 POINT CONCENTRATION
C                  3    USE THE 1/3 POINT CONCENTRATION
C                  4    USE THE 1/4 POINT CONCENTRATION
C                  5    USE THE 2-WAY PROPORTIONAL CONCENTRATION
C
      COMMON /MISC/   CTIME, DELTQ, ICYC, NC, NJ, NPP, NUMCON,
     *                RMNODE(133), STIME
      COMMON /CHAN/   AREA(139), B(139), CLEN(139), CN(139), DIFFK(139),
     *                NJUNC(139,2), Q(139), QNET(139), R(139), V(139)
      COMMON /QUAL/   C(133,6), CMASS(133,6)
C
      DO 700 N=1,NC
        VOLFLW = Q(N) * DELTQ
        DIFFC  = DIFFK(N) * R(N) * ABS(Q(N))
        NL = NJUNC(N,1)
        NH = NJUNC(N,2)
      DO 602 K=1,NUMCON
        CA = C(NL,K)
        CB = C(NH,K)
        IF (N.EQ.65) GO TO 100
        GO TO (100,200,300,400,500), MIX
C*********************************  UPSTREAM CONCENTRATION  ***************************
  100     IF (Q(N).GE.0) CONC = CA
          IF (Q(N).LT.0) CONC = CB
          GO TO 600
C***************************  1/2 POINT CONCENTRATION  *****************************
  200     CONC = (CA + CB) / 2.
          GO TO 600
C***************************  1/3 POINT CONCENTRATION  ***************************
  300     IF (Q(N).GE.0) CONC = (2.*CA + CB) / 3.
          IF (Q(N).LT.0) CONC = (CA + 2.*CB) / 3.
          GO TO 600
C***************************  1/4 POINT CONCENTRATION  ****************************
  400     IF (Q(N).GE.0) CONC = (3.*CA + CB) / 4.
          IF (Q(N).LT.0) CONC = (CA + 3.*CB) / 4.
          GO TO 600
C***********************  2-WAY PROPORTIONAL CONCENTRATION  **********************
  500     CONC = (CA + CB)/2. + ((CA-CB)/2. * V(N) * DELTQ / CLEN(N))
C*******************  COMPUTE ADVECTED AND DIFFUSED MASSES  *********************
  600 CONTINUE
              ADMASS = CONC * VOLFLW
              DIMASS = DIFFC * (CA - CB)
              CMASS(NH,K) = CMASS(NH,K) + ADMASS + DIMASS
              CMASS(NL,K) = CMASS(NL,K) - ADMASS - DIMASS
  602       CONTINUE
  700 CONTINUE
      RETURN
      END
```

```
C*******************************************************************************
C                             SUBROUTINE SUMARY
C*******************************************************************************

      SUBROUTINE SUMARY(IP,LP,PLT,NUM)

      DIMENSION  CAVG1(133,6), CAVG2(133,6), CMAX1(133,6), CMAX2(133,6),
     *           CMIN1(133,6), CMIN2(133,6)
      COMMON /MISC/   CTIME, DELTQ, ICYC, MC, NJ, NPP, NUMCON,
     *                RMNODE(133), STIME
      COMMON /SUMSUM/ FGOXA(49), FGOXO(3,6,49), HOURS1, HOURS2,
     *                KDAYS1, KDAYS2
      COMMON /QUAL/   C(133,6), CMASS(133,6)

      GO TO (100,124), NUM

C***************************   IMITIALIZE SUMMARY 1   ***************************

  100 IF (ICYC.GT.IP) GO TO 106
        DO 104 K=1,NUMCON
          DO 102 J=1,NJ
            CMIN1(J,K) = C(J,K)
            CMAX1(J,K) = C(J,K)
            CAVG1(J,K) = C(J,K)
  102     CONTINUE
  104   CONTINUE
        RETURN
  106 CONTINUE

C*************************   COMPUTE MIN, MAX, AVG   **************************

      DO 110 K=1,NUMCON
        DO 108 J=1,NJ
          IF (C(J,K).LT.CMIN1(J,K))  CMIN1(J,K) = C(J,K)
          IF (C(J,K).GT.CMAX1(J,K))  CMAX1(J,K) = C(J,K)
          CAVG1(J,K) = CAVG1(J,K) + C(J,K)
  108   CONTINUE
  110 CONTINUE
      IF (ICYC.NE.LP) RETURN
      DO 114 K=1,NUMCON
        DO 112 J=1,NJ
          CAVG1(J,K) = CAVG1(J,K) / FLOAT(LP - IP + 1)
  112   CONTINUE
  114 CONTINUE

C***************************   WRITE SUMMARY TABLE 1   *************************

      HOURS1 = DELTQ * FLOAT(IP) / 3600.
      HOURS2 = DELTQ * FLOAT(LP) / 3600.
      KDAYS1 = HOURS1 / 24.
      KDAYS2 = HOURS2 / 24.
      HOURS1 = HOURS1 - FLOAT(24 * KDAYS1)
      HOURS2 = HOURS2 - FLOAT(24 * KDAYS2)
      WRITE (6,600) IP, KDAYS1, HOURS1, LP, KDAYS2, HOURS2
      WRITE (6,602)
      DO 116 J=1,NJ
        WRITE (6,604)J, (CMIN1(J,K), CMAX1(J,K), CAVG1(J,K), K=1,NUMCON)
  116 CONTINUE

C*********************   CHECK FOR PLOTTING OF SUMMARY 1   *********************
```

```
      IF (PLT.EQ.0) GO TO 122
      NPP = 0
      DO 120 J=1,NJ
        IF (J.GT.43.AND.J.NE.114.AND.J.NE.129.AND.J.NE.130) GO TO 120
        NPP = NPP + 1
        IF (NPP.GT.99) WRITE (6,606)
          DO 118 LPP=1,NUMCON
            FGOXO(1,LPP,NPP) = CMAX1(J,LPP)
            FGOXO(2,LPP,NPP) = CAVG1(J,LPP)
            FGOXO(3,LPP,NPP) = CMIN1(J,LPP)
  118     CONTINUE
        FGOYA(NPP) = RMNODE(J)
  120 CONTINUE
      CALL SUMPLT(IP,LP)
  122 CONTINUE
      RETURN

C**************************   INITIALIZE SUMMARY 2   **************************

  124 IF (ICYC.GT.IP) GO TO 130
        DO 128 K=1,NUMCON
          DO 126 J=1,NJ
            CMIN2(J,K) = C(J,K)
            CMAX2(J,K) = C(J,K)
            CAVG2(J,K) = C(J,K)
  126     CONTINUE
  128   CONTINUE
        RETURN
  130 CONTINUE

C**************************   COMPUTE MIN, MAX, AVG   **************************

      DO 134 K=1,NUMCON
        DO 132 J=1,NJ
          IF (C(J,K).LT.CMIN2(J,K))  CMIN2(J,K) = C(J,K)
          IF (C(J,K).GT.CMAX2(J,K))  CMAX2(J,K) = C(J,K)
          CAVG2(J,K) = CAVG2(J,K) + C(J,K)
  132   CONTINUE
  134 CONTINUE
      IF (ICYC.NE.LP) RETURN
      DO 138 K=1,NUMCON
        DO 136 J=1,NJ
          CAVG2(J,K) = CAVG2(J,K) / FLOAT(LP - IP + 1)
  136   CONTINUE
  138 CONTINUE

C**************************   WRITE SUMMARY TABLE 2   **************************

      HOURS1 = DELTO * FLOAT(IP) / 3600.
      HOURS2 = DELTO * FLOAT(LP) / 3600.
      KDAYS1 = HOURS1 / 24.
      KDAYS2 = HOURS2 / 24.
      HOURS1 = HOURS1 - FLOAT(24 * KDAYS1)
      HOURS2 = HOURS2 - FLOAT(24 * KDAYS2)
      WRITE (6,600) IP, KDAYS1, HOURS1, LP, KDAYS2, HOURS2
      WRITE (6,602)
      DO 140 J=1,NJ
        WRITE (6,604)J, (CMIN2(J,K), CMAX2(J,K), CAVG2(J,K), K=1,NUMCON)
  140 CONTINUE
```

```
C*********************   CHECK FOR PLOTTING OF SUMMARY 2   ********************

      IF (PLT.EQ.0) GO TO 146
      NPP = 0
      DO 144 J=1,NJ
        IF (J.GT.43.AND.J.NE.114.AND.J.NE.129.AND.J.NE.130) GO TO 144
        NPP = NPP + 1
        IF (NPP.GT.99) WRITE (6,606)
          DO 142 LPP=1,NUMCON
            FGQXO(1,LPP,NPP) = CMAX2(J,LPP)
            FGQXO(2,LPP,NPP) = CAVG2(J,LPP)
            FGQXO(3,LPP,NPP) = CMIN2(J,LPP)
  142     CONTINUE
        FGQYA(NPP) = RMNODE(J)
  144 CONTINUE
      CALL SUMPLT(IP,LP)

  146 CONTINUE
C*************************************************************************
C                                FORMAT STATEMENTS
C*************************************************************************

600   FORMAT (1H1///10X,45(1H*),'      WATER QUALITY SUMMARY      ',45(1H*
     *)/ ,13X,'STARTS AT CYCLE ',I4,' (',I3,' DAYS ',F4.1,' HOURS)',31X,
     *'ENDS AT CYCLE ',I4,' (',I3,' DAYS ',F4.1,' HOURS)'// )
602   FORMAT (1H //TX,'JUNC.   CONSTITUENT 1       CONSTITUENT 2       C
     *ONSTITUENT 3       CONSTITUENT 4        CONSTITUENT 5          CO
     *NSTITUENT 6',/,8X,'MIN   MAX   AVG     MIN   MAX   AVG     MIN   M
     *AX   AVG    MIN    MAX   AVG      MIN    MAX    AVG      MIN    M
     *AX    AVG',/,1X,130(1H-)/ )
604   FORMAT (1X,I3,1X,3(1X,F5.2),2X,3(1X,F5.2),2X,3(1X,F5.2),1X,3(2X,F5
     *.1),1X,3(2X,F5.2),2X,3(2X,F5.2) )
606   FORMAT('1  NUMBER OF PLOTTER PTS EXCEEDS ARRAY DIMENSIONS')
      RETURN
      END
```

```
C***********************************************************************
C                             SUMPLT
C***********************************************************************

      SUBROUTINE SUMPLT(IP,LP)

      DIMENSION  BOT1(12), NPT(3), SIDE1(51), SIDE2(6), X(99,3), Y(99,3)
      COMMON /MISC/   CTIME, DELTQ, ICYC, NC, NJ, NPP, NUMCON,
     *                RMNODE(133), STIME
      COMMON /SUMSUM/ FGQXA(49), FGQXO(3,6,49), HOURS1, HOURS2,
     *                KDAYS1, KDAYS2
      COMMON /SCALES/ XMAX, XMIN, YMAX, YMAXC(6), YMIN, YMINC(6)
      COMMON /AXES/   BOTTOM(12), SIDE(51)

      DATA BOT1/6*4H    ,4HMILE,4HS BE,4HLOW ,4HCHAI,4HN BR,4HIDGE /
      DATA SIDE1/21*1H ,1HC,1HO,1HN,1HS,1HT,1HI,1HT,1HU,1HE,1HN,1HT,
     1  19*1H /
      DATA SIDE2/1H1,1H2,1H3,1H4,1H5,1H6/

      XMIN=0.1
      XMAX=49.9
C*****************   SET LABELS ON SIDE AND BOTTOM AXES   ***********************
      DO 100 I=1,51
        SIDE(I) = SIDE1(I)
  100 CONTINUE
      DO 102 I=1,12
        BOTTOM(I) = BOT1(I)
  102 CONTINUE
      DO 106 II=1,NUMCON
C***************   FILL UP X & Y ARRAYS WITH DATA TO BE PLOTTED   ************
        DO 104 I=1,NPP
          Y(I,1) = FGQXO(1,II,I)
          Y(I,2) = FGQXO(2,II,I)
          Y(I,3) = FGQXO(3,II,I)
          X(I,1) = FGQXA(I)
          X(I,2) = FGQXA(I)
          X(I,3) = FGQXA(I)
  104   CONTINUE
        NPT(1) = NPP
        NPT(2) = NPP
        NPT(3) = NPP
C******************   SET SIDE LABELS FOR CONSTITUENT NO.   ********************
        SIDE(34) = SIDE2(II)
C****************************   WRITE OUT TITLE   ******************************
        WRITE (22,600)
        WRITE (22,602) IP, KDAYS1, HOURS1, LP, KDAYS2, HOURS2
        YMIN = YMINC(II)
        YMAX = YMAXC(II)
C***********************   CALL CURVE TO PRODUCE THE PLOT   ********************
        CALL CURVE (X,Y,NPT,3,1,0,2,0,1)
  106 CONTINUE
      RETURN

C***************************  FORMAT STATEMENTS  ******************************

  600 FORMAT(1H1,34X,'POTOMAC ESTUARY CENTER CHANNEL - QUALITY SUMMARY')
  602 FORMAT(1H ,32X,'SUMMARY STARTS AT CYCLE',2I6,' DAYS',F5.1,' HOURS'
     */33X,'SUMMARY  ENDS  AT CYCLE',2I6,' DAYS',F5.1,' HOURS')
      END
```

```
C*******************************************************************************
C                                  SUBROUTINE SWTABL
C*******************************************************************************

      SUBROUTINE SWTABL(I,M)

      COMMON /MISC/   CTIME, DELTO, ICYC, NC, NJ, NPP, NUNCON,
     *                RMNODE(133), STIME
      COMMON /SLACK/  JPRT(150,55), KSL(20), KPLOT(20), NFPC(20),
     *                NLPC(20), NOPRT(150), NCONSW(5), NSWP
      COMMON /SWTSWP/ FGSWA(99),FGSWO(99,6), IMPOSE,INFPC,INLPC,KSLACK
      COMMON /JUNC/   ASUR(133), AVOL(133), NCHAN(133,5), VOL(133),
     *                Y(133), YNEW(133)
      COMMON /QUAL/   C(133,6), CMASS(133,6)

      IF (ICYC.GT.0) GO TO 152
      IF (KSL(M).EQ.0) GO TO 150
      IF (KSL(M).EQ.1) GO TO 100
      IF (KSL(M).EQ.2) GO TO 124

C*********************  SET HIGH SLACK TABLE PARAMETERS   *********************

  100 NSWCYC = 10
      NLPC(M) = NFPC(M) + NSWCYC
          NOPRT(I) = 2
            JPRT(I,1) =  1
            JPRT(I,2) = 65
      DO 122 II=1,NSWCYC
        I=I+1
        GO TO (102,104,106,108,110,112,114,116,118,120), II
  102     NOPRT(I) = 4
            JPRT(I,1)  = 64
            JPRT(I,2)  = 63
            JPRT(I,3)  = 62
            JPRT(I,4)  = 61
            GO TO 122
  104     NOPRT(I) = 3
            JPRT(I,1)  = 60
            JPRT(I,2)  = 59
            JPRT(I,3)  = 58
            GO TO 122
  106     NOPRT(I) = 1
            JPRT(I,1)  = 57
            GO TO 122
  108     NOPRT(I) = 3
            JPRT(I,1)  = 56
            JPRT(I,2)  = 55
            JPRT(I,3)  = 54
            GO TO 122
  110     NOPRT(I) = 5
            JPRT(I,1)  = 53
            JPRT(I,2)  = 52
            JPRT(I,3)  = 51
            JPRT(I,4)  = 50
            JPRT(I,5)  = 49
            GO TO 122
  112     NOPRT(I) = 5
            JPRT(I,1)  = 48
            JPRT(I,2)  = 47
            JPRT(I,3)  = 46
            JPRT(I,4)  = 45
            JPRT(I,5)  = 44
            GO TO 122
  114     NOPRT(I) = 8
            JPRT(I,1)  = 43
            JPRT(I,2)  = 42
            JPRT(I,3)  = 41
            JPRT(I,4)  = 40
            JPRT(I,5)  = 39
            JPRT(I,6)  = 38
            JPRT(I,7)  = 37
            JPRT(I,8)  = 36
            GO TO 122
  116     NOPRT(I) = 7
            JPRT(I,1)  = 35
            JPRT(I,2)  = 34
            JPRT(I,3)  = 33
            JPRT(I,4)  = 32
            JPRT(I,5)  = 31
            JPRT(I,6)  = 30
            JPRT(I,7)  = 29
            GO TO 122
  118     NOPRT(I) = 24
            JPRT(I,1)  = 28
            JPRT(I,2)  = 27
            JPRT(I,3)  = 26
            JPRT(I,4)  = 25
            JPRT(I,5)  = 24
            JPRT(I,6)  = 23
            JPRT(I,7)  = 22
            JPRT(I,8)  = 21
            JPRT(I,9)  = 20
            JPRT(I,10) = 19
            JPRT(I,11) = 18
            JPRT(I,12) = 17
            JPRT(I,13) = 16
            JPRT(I,14) = 15
            JPRT(I,15) = 14
            JPRT(I,16) =130
            JPRT(I,17) =129
            JPRT(I,18) = 13
            JPRT(I,19) = 12
            JPRT(I,20) = 11
            JPRT(I,21) = 10
            JPRT(I,22) =  9
            JPRT(I,23) =  8
            JPRT(I,24) =  7
            GO TO 122
  120     NOPRT(I) = 6
            JPRT(I,1)  =  6
            JPRT(I,2)  =  5
            JPRT(I,3)  =  4
            JPRT(I,4)  =  3
            JPRT(I,5)  =  2
            JPRT(I,6)  =114
  122 CONTINUE
      RETURN
  124 CONTINUE

C********************   SET LOW SLACK TABLE PARAMETERS   **********************
```

```
      NSWCYC = 11
      NLPC(M) = NFPC(M) + NSWCYC
         NOPRT(I) = 7
           JPRT(I,1)  =  1
           JPRT(I,2)  = 65
           JPRT(I,3)  = 64
           JPRT(I,4)  = 63
           JPRT(I,5)  = 62
           JPRT(I,6)  = 61
           JPRT(I,7)  = 60
       DO 148 II=1,NSWCYC
         I = I + 1
         GO TO (126,128,130,132,134,136,138,140,142,144,146), II
 126     NOPRT(I) = 2
           JPRT(I,1)  = 59
           JPRT(I,2)  = 58
           GO TO 148
 128     NOPRT(I) = 1
           JPRT(I,1)  = 57
           GO TO 148
 130     NOPRT(I) = 3
           JPRT(I,1)  = 56
           JPRT(I,2)  = 55
           JPRT(I,3)  = 54
           GO TO 148
 132     NOPRT(I) = 4
           JPRT(I,1)  = 53
           JPRT(I,2)  = 52
           JPRT(I,3)  = 51
           JPRT(I,4)  = 50
           GO TO 148
 134     NOPRT(I) = 3
           JPRT(I,1)  = 49
           JPRT(I,2)  = 48
           JPRT(I,3)  = 47
           GO TO 148
 136     NOPRT(I) = 5
           JPRT(I,1)  = 46
           JPRT(I,2)  = 45
           JPRT(I,3)  = 44
           JPRT(I,4)  = 43
           JPRT(I,5)  = 42
           GO TO 148
 138     NOPRT(I) = 6
           JPRT(I,1)  = 41
           JPRT(I,2)  = 40
           JPRT(I,3)  = 39
           JPRT(I,4)  = 38
           JPRT(I,5)  = 37
           JPRT(I,6)  = 36
           GO TO 148
 140     NOPRT(I) = 7
           JPRT(I,1)  = 35
           JPRT(I,2)  = 34
           JPRT(I,3)  = 33
           JPRT(I,4)  = 32
           JPRT(I,5)  = 31
           JPRT(I,6)  = 30
           JPRT(I,7)  = 29
```

```
          GO TO 148
  142   NOPRT(I) = 12
          JPRT(I,1)  = 28
          JPRT(I,2)  = 27
          JPRT(I,3)  = 26
          JPRT(I,4)  = 25
          JPRT(I,5)  = 24
          JPRT(I,6)  = 23
          JPRT(I,7)  = 22
          JPRT(I,8)  = 21
          JPRT(I,9)  = 20
          JPRT(I,10) = 19
          JPRT(I,11) = 18
          JPRT(I,12) = 17
          GO TO 148
  144   NOPRT(I) = 12
          JPRT(I,1)  = 16
          JPRT(I,2)  = 15
          JPRT(I,3)  = 14
          JPRT(I,4)  = 130
          JPRT(I,5)  = 129
          JPRT(I,6)  = 13
          JPRT(I,7)  = 12
          JPRT(I,8)  = 11
          JPRT(I,9)  = 10
          JPRT(I,10) =  9
          JPRT(I,11) =  8
          JPRT(I,12) =  7
          GO TO 148
  146   NOPRT(I) = 6
          JPRT(I,1)  =  6
          JPRT(I,2)  =  5
          JPRT(I,3)  =  4
          JPRT(I,4)  =  3
          JPRT(I,5)  =  2
          JPRT(I,6) = 114
  148 CONTINUE
      RETURN
  150 CONTINUE
C*********************   SET SNAPSHOT TABLE PARAMETERS   **********************

      NLPC(M) = NFPC(M)
         NOPRT(I) = 53
           JPRT(I,1) = 114
           JPRT(I,2)  =  2
           JPRT(I,3)  =  3
           JPRT(I,4)  =  4
           JPRT(I,5)  =  5
           JPRT(I,6)  =  6
           JPRT(I,7)  =  7
           JPRT(I,8)  =  8
           JPRT(I,9)  =  9
           JPRT(I,10) = 10
           JPRT(I,11) = 11
           JPRT(I,12) = 12
           JPRT(I,13) = 13
           JPRT(I,14) =129
           JPRT(I,15) =130
           JPRT(I,16) = 14
```

```
            JPRT(I,17) = 15
            JPRT(I,18) = 16
            JPRT(I,19) = 17
            JPRT(I,20) = 18
            JPRT(I,21) = 19
            JPRT(I,22) = 20
            JPRT(I,23) = 21
            JPRT(I,24) = 22
            JPRT(I,25) = 23
            JPRT(I,26) = 24
            JPRT(I,27) = 25
            JPRT(I,28) = 26
            JPRT(I,29) = 27
            JPRT(I,30) = 28
            JPRT(I,31) = 29
            JPRT(I,32) = 30
            JPRT(I,33) = 31
            JPRT(I,34) = 32
            JPRT(I,35) = 33
            JPRT(I,36) = 34
            JPRT(I,37) = 35
            JPRT(I,38) = 36
            JPRT(I,39) = 38
            JPRT(I,40) = 40
            JPRT(I,41) = 42
            JPRT(I,42) = 44
            JPRT(I,43) = 46
            JPRT(I,44) = 48
            JPRT(I,45) = 50
            JPRT(I,46) = 52
            JPRT(I,47) = 54
            JPRT(I,48) = 56
            JPRT(I,49) = 58
            JPRT(I,50) = 60
            JPRT(I,51) = 62
            JPRT(I,52) = 64
            JPRT(I,53) =  1
      RETURN
  152 CONTINUE

C************************   PRINT SLACK WATER TABLE   *************************

      HOURS = DELTO * FLOAT(ICYC) / 3600. + STIME
      KDAYS = HOURS / 24.
      HOURS = CTIME
      IF (KSL(M).EQ.0) GO TO 140
      IF (ICYC.EQ.NFPC(M)) GO TO 154

C*********************   CONTINUE OLD SLACK WATER TABLE   *********************

        WRITE (6,600)
        WRITE (6,602) ICYC, KDAYS, HOURS
        GO TO 162
  154 CONTINUE

C*********************   BEGIN NEW SLACK WATER TABLE   ************************

      NPP = 0
      IF (KSL(M).EQ.2) GO TO 156
        WRITE (6,604)
        GO TO 158
  156 CONTINUE
      WRITE (6,606)
  158 CONTINUE
      WRITE (6,608) ICYC, KDAYS, HOURS
      GO TO 162
  160 CONTINUE

C**************************   BEGIN SNAPSHOT TABLE   ****************************

      NPP = 0
      WRITE (6,610) ICYC, KDAYS, HOURS
  162 CONTINUE

C**********************   PRINT DATA FROM PRESENT CYCLE   ***********************

      NOP = NOPRT(I)
        DO 166 L=1,NOP
          J = JPRT(I,L)
          WRITE (6,612) J, Y(J), (C(J,K), K=1,NUMCON)

C*************************   PREPARE TO PLOT DATA   *****************************

          IF (MSWP.EQ.0) GO TO 166
          IF (KPLOT(M).EQ.0) GO TO 166
          IF (J.GT.43.AND.J.NE.114.AND.J.NE.129.AND.J.NE.130) GO TO 165
            NPP = NPP + 1
            IF (NPP.GT.99) WRITE (6,614)
              DO 164 LPP=1,NUMCON
                FGSWO(NPP,LPP) = C(J,LPP)
  164         CONTINUE
            FGSWA(NPP) = RMNODE(J)
  166   CONTINUE
          IF (ICYC.NE.NLPC(M)) RETURN
          IF (KPLOT(M).EQ.0) RETURN
            IMPOSE = KPLOT(M)
            KSLACK = KSL(M)
            INFPC  = NFPC(M)
            INLPC  = NLPC(M)
            CALL SWPLOT
  168   CONTINUE

C*******************************************************************************
C                                FORMAT STATEMENTS
C*******************************************************************************

600   FORMAT (1X,130(1H-) /)
602   FORMAT (1H ,32X,' CYCLE',I5,I12,' DAYS,',F6.2,' HOURS',/ )
604   FORMAT(1H1//48X,23H HIGH SLACK PREDICTIONS/)
606   FORMAT(1H1/ 48X,23H  LOW SLACK PREDICTIONS/)
608   FORMAT (1H  / 3X,'JUNCTION   HEAD     CONSTITUENT 1    CONSTITUENT
     * 2    CONSTITUENT 3    CONSTITUENT 4    CONSTITUENT 5    CONSTITUE
     *NT 6',/,14X,'(FT)',8X,'(MG/L)           (MG/L)           (MG/L)
     *         (UG/L)           (MG/L)           (MG/L)',/ 1X,130(1H-),//
     *33X,' CYCLE',I5,I12,' DAYS,',F6.2,' HOURS'/ )
610   FORMAT (1H1/// 25X,'SYSTEM STATUS AFTER QUALITY CYCLE',I6,I10,' DA
     *YS, ',F6.2,' HOURS',//,3X,'JUNCTION   HEAD     CONSTITUENT 1    CO
     *NSTITUENT 2    CONSTITUENT 3    CONSTITUENT 4    CONSTITUENT 5
     *CONSTITUENT 6',/,14X,'(FT)',8X,'(MG/L)           (MG/L)
     *(MG/L)           (UG/L)           (MG/L)           (MG/L)',/,1X,13
     *0(1H-))
612   FORMAT (5X,I3,4X,F6.2,8X,F6.2,5(11X,F6.2))
614   FORMAT (1H1///20X,'NUMBER OF PLOTTER POINTS EXCEEDS ARRAY SIZE')
      RETURN
      END
```

```
C*******************************************************************************
C                              SWPLOT
C*******************************************************************************

      SUBROUTINE SWPLOT

      DIMENSION  BOT1(12), NPT(3), SIDE1(51), SIDE2(6), X(99,3), Y(99,3)
      COMMON /MISC/   CTIME, DELTO, ICYC, NC, NJ, NPP, NUMCON,
     *                RMNODE(133), STIME
      COMMON /SLACK/  JPRT(150,55), KSL(20), KPLOT(20), NFPC(20),
     *                NLPC(20), NOPRT(150), NCONSW(6), NSWP
      COMMON /SWTSWP/ FGSWA(99),FGSWO(99,6), IMPOSE,INFPC,INLPC,KSLACK
      COMMON /OBSDAT/ OBDATA(3,6,20), RMDATA(20), NDATA, NOBCYC(10)
      COMMON /SCALES/ XMAX, XMIN, YMAX, YMAXC(6), YMIN, YMINC(6)
      COMMON /AXES/   BOTTOM(12), SIDE(51)

      DATA BOT1/6*4H    ,4HMILE,4HS BE,4HLOW ,4HCHAI,4HN BR,4HIDGE /
      DATA SIDE1/21*1H ,1HC,1HO,1HN,1HS,1HT,1HI,1HT,1HU,1HE,1HN,1HT,
     1  19*1H /
      DATA SIDE2/1H1,1H2,1H3,1H4,1H5,1H6/

      XMIN=0.1
      XMAX=49.9

C***************    SET LABELS ON SIDE AND BOTTOM AXES   ***********************

      DO 100 I=1,51
        SIDE(I) = SIDE1(I)
  100 CONTINUE
      DO 102 I=1,12
        BOTTOM(I) = BOT1(I)
  102 CONTINUE
      DO 132 II=1,NUMCON
        IF (NCONSW(II).NE.1) GO TO 132
        IF (IMPOSE.LT.4) GO TO 104
        IF (II.LT.6) GO TO 132
  104   CONTINUE
        IMPCHK = II + IMPOSE

C**************    FILL UP X & Y ARRAYS WITH DATA TO BE PLOTTED   **************
C***************************   INITIALIZE COUNTERS   ***************************

        IF (IMPOSE.EQ.4) GO TO 106
        IC = 0
  106   CONTINUE
        ICP = 0
          DO 110 I=1,NPP
            IF (IMPOSE.LT.4) GO TO 108
            ICP = ICP + 1
            X(ICP,2) = FGSWA(I)
            Y(ICP,2)  = FGSWO(I,6)
            GO TO 110
  108       CONTINUE
            IC = IC + 1
            X(IC,1) = FGSWA(I)
            Y(IC,1) = FGSWO(I,II)
  110     CONTINUE
        NPT(1) = IC
        NPT(2) = ICP
```

```
C******************   SET SIDE LABELS FOR CONSTITUENT NO.   ********************

       SIDE(34) = SIDE2(II)

C*********************   CHECK FOR OVERLAY FOR CONSTITUENT 6   *****************

       IF (IMPCHK.LT.9) GO TO 114
       IF (IMPOSE.EQ.4) GO TO 112
       ISAVE  = INFPC
       ISAVE1 = INLPC
       ISAVE2 = KSLACK
       KTITLE = 0
       RETURN
  112  CONTINUE
  114  CONTINUE

C****************************   WRITE OUT TITLE   ******************************

       WRITE (22,600)
       K = KSLACK + 1
  116  GO TO (118,122,120), K
  118  WRITE (22,602) INFPC
       GO TO 124
  120  WRITE (22,604) INFPC, INLPC
       GO TO 124
  122  WRITE (22,606) INFPC, INLPC
  124  CONTINUE
       IF (IMPCHK.LT.10) GO TO 126
       IF (KTITLE.EQ.1) GO TO 126
       K = ISAVE2 + 1
       INFPC  = ISAVE
       INLPC  = ISAVE1
       KTITLE  = 1
       GO TO 116
  126  YMIN  = YMINC(II)
       YMAX   = YMAXC(II)
       ISTAN = II
       ISIDE = 1
       IF (NDATA.EQ.0) ISTAN = 0

C***********************   CALL CURVE TO PRODUCE THE PLOT   ********************

       IF (IMPOSE.LT.4) GO TO 128
       CALL CURVE (X,Y,NPT,2,1,0,2,ISTAN,ISIDE)
       GO TO 130
  128  CONTINUE
       CALL CURVE (X,Y,NPT,1,1,0,2,ISTAN,ISIDE)
  130  CONTINUE
  132 CONTINUE
     RETURN

C****************************  FORMAT STATEMENTS  ******************************

  600 FORMAT(1H1,44X,'POTOMAC ESTUARY CENTER CHANNEL')
  602 FORMAT(1H0,45X,'PROFILE PLOT FOR CYCLE',I6)
  604 FORMAT(1H0,36X,'   LOW  WATER SLACK PLOT FROM CYCLE',I5,' TO CYCLE'
     *,I5)
  606 FORMAT(1H0,39X,'HIGH WATER SLACK PLOT FROM CYCLE',I5,' TO CYCLE',
     *I5)
      END
```

```
C***********************************************************************
C                                   TPLOT
C***********************************************************************

      SUBROUTINE TPLOT

      DIMENSION  C(6), BOT1(12), NPT(3), SIDE1(51), SIDE2(6),
     *    X(99,3), Y(99,3)
      COMMON /MISC/   CTIME, DELTQ, ICYC, MC, NJ, NPP, NUMCON,
     *                RMNODE(133), STIME
      COMMON /TIMEPL/ JUNCTP(20), NCITP(20), NCONTP(20,6), NECTP(20),
     *                NSCTP(20), NTP
      COMMON /SCALES/ XMAX, XMIN, YMAX, YMAXC(6), YMIN, YMINC(6)
      COMMON /AXES/   BOTTOM(12), SIDE(51)

      DATA SIDE1/21*1H ,1HC,1HO,1HN,1HS,1HT,1HI,1HT,1HU,1HE,1HN,1HT,
     1  19*1H /
      DATA SIDE2/1H1,1H2,1H3,1H4,1H5,1H6/
      DATA BOT1/9*4H    ,4HCYCL,4HES  ,4H    /

C********************************   SET LABELS   ********************************

      DO 100 I = 1,51
        SIDE(I) = SIDE1(I)
  100 CONTINUE
      DO 102 I=1,12
        BOTTOM(I) = BOT1(I)
  102 CONTINUE

C**************************   SET UP TIME PLOTS   ******************************

      DO 120 II=1,NTP
        DO 118 JJ=1,NUMCON
          REWIND 11
          IF (NCONTP(II,JJ).NE.1) GO TO 118
          YMIN = YMINC(JJ)
          YMAX = YMAXC(JJ)

C********************   SKIP TO STARTING CYCLE   ******************************

          M  = NSCTP(II)
          L1 = (M-1) * NTP
          IF (L1.EQ.0) GO TO 106
            DO 104 L=1,L1
              READ (11) ICYC, (C(K),K=1,NUMCON)
  104       CONTINUE
  106     CONTINUE
          II1 = II
          KK = 0
          ITIM1 = NSCTP(II)
          ITIM2 = NECTP(II)
          ITIM3 = NCITP(II)

C********************   LOOP FOR SPECIFIED PLOTTING CYCLES   *****************

          DO 116 I=ITIM1,ITIM2,ITIM3
            KK = KK + 1

C*************   SKIP TO THEN READ PLOTTING JUNCTION IN PRESENT CYCLE   ********
```

```
                DO 108 L=1,II1
                  READ (11) ICYC, (C(K),K=1,NUMCON)
  108           CONTINUE
              Y(KK,1) = C(JJ)
              X(KK,1) = I
              II2 = NTP * (NCITP(II) - 1)
              L2  = NTP - II

C*****************   SKIP TO END OF PRESENT CYCLE   ***************************

              IF (L2.EQ.0) GO TO 112
                DO 110 L=1,L2
                  READ (11) ICYC,(C(K),K=1,NUMCON)
  110           CONTINUE
  112         CONTINUE

C*****************   SKIP TO START OF NEXT PLOTTING CYCLE   ********************

              IF (II2.EQ.0) GO TO 116
              III = I + ITIM3
              IF (III.GT.ITMI2) GO TO 116
                DO 114 LL=1,II2
                  READ (11) ICYC,(C(K),K=1,NUMCON)
  114           CONTINUE
  116       CONTINUE

C**********************   SET UP SIDE LABELS   **********************************

            SIDE(34) = SIDE2(JJ)

C**********************   WRITE OUT TITLE   **************************************

            WRITE (22,600) JUNCTP(II), NCITP(II)

C**********************   CALL CURVE TO PRODUCE PLOT   **************************

            NPT(1) = KK
            XMIN   = NSCTP(II)
            XMAX   = NECTP(II)
            CALL CURVE (X,Y,NPT,1,1,0,2,0,1)
  118     CONTINUE
  120 CONTINUE
      RETURN

C***************************   FORMAT STATEMENTS   ********************************

  600 FORMAT(1H1,40X,' TIME PLOTS FOR NODE',I5,' AT AN INTERVAL OF',I5,
     1  '  CYCLES')
      END
```

```
C*0*********************************************************************
C                                 CURVE
C***********************************************************************
C       CURVE IS THE ENTRY TO A GENERALIZED PRINTER PLOT ROUTINE. THE
C    ROUTINE PLOTS SEQUENTIALLY PAIRED VALUES TAKEN FROM THE X AND Y
C    ARRAYS. THE SCALING VALUES FOR BOTH ARRAYS ARE STORED IN THE LAST
C    TWO ARRAY LOCATIONS IN THE SAME MANNER AS CALCOMP SCALING. THE
C    ARGUEMENTS IN THE SCALING SEQUENCE ARE DEFINED AS...
C          X = THE ARRAY CONTAINING THE X-AXIS COORDINATES OF THE POINTS
C              TO BE PLOTTED
C          Y = THE ARRAY CONTAINING THE Y-AXIS COORDINATES OF THE POINTS
C              TO BE PLOTTED
C        NPT = THE NUMBER OF POINTS TO BE PLOTTED
C        NCV = THE NUMBER OF CURVES TO BE PLOTTED
C      NPLOT = USED FOR PLOT IDENTIFICATION, THIS VALUE IS PRINTED ABOVE
C              EACH PLOT FOR EACH CALL TO CURVE
C      IJOIN = FLAG FOR JOINING OR NO JOINING OF POINTS
C       ITEL = FLAG FOR GRID SIZE
C      ISTAN = CONSTITUENT NUMBER
C      ISIDE = 1 FOR CENTER CHANNEL
C***********************************************************************
      SUBROUTINE CURVE(X,Y,NPT,NCV,NPLOT,IJOIN,ITEL,ISTAN,ISIDE)
      COMMON /OBSDAT/ OBDATA(3,6,20), PMDATA(20), NDATA, NOBCYC(10)
      COMMON /SCALES/ XMAX, XMIN, YMAX, YMAXC(6), YMIN, YMINC(6)
      COMMON /CURPLT/ JSTAN, XLAB(11), XAXIS, YAXIS, YLAB(6), YSTAN
      DIMENSION  NPT(3), X(99,3), Y(99,3)
C*******************   SET SPECIAL GRID SIZE IF DESIRED   ***************
      JSTAN=0                                                           1063=
      IF(ITEL-1) 1000,1010,1020                                         1089.
 1010 XAXIS=60.                                                         1090.
      YAXIS=40.                                                         1091.
      GO TO 1000                                                        1092.
 1020 XAXIS=100.                                                        1093.
      YAXIS=50.                                                         1094.
 1000 NPTS=NPT(1)                                                       1095.
C*******************   SET UP X AND Y SCALES   **************************
      IXAX=XAXIS/10.                                                    1098.
      IYAX=YAXIS/10.                                                    1099.
      IXAX1=IXAX+1                                                      1100.
      IYAX1=IYAX+1                                                      1101.
C*******************   FIND MAX AND MIN FOR X AND Y ARRAY   *************
 2001 CONTINUE                                                          1117=
C**************************   SET UP SCALES   **************************
      AXLEN=IXAX                                                        1121.
      CALL SCALE(X,XMAX,XMIN,AXLEN,NPTS,1)                              1122.
      AXLEN=IYAX                                                        1123.
      CALL SCALE(Y,YMAX,YMIN,AXLEN,NPTS,1)                              1124.
C*******************   FORM X LABELS AND FACTORS   **********************
      XMIN=X(NPTS+1,1)                                                  1128.
      DELTX=X(NPTS+2,1)                                                 1129.
      XLAB(1)=XMIN                                                      1130.
      DO 260 I=1,IXAX                                                   1131.
  260 XLAB(I+1)=XLAB(I)+DELTX                                           1132.
      XSCAL=XAXIS/(XLAB(IXAX1)-XMIN)                                    1133.
```

```
C*********************   FORM Y LABELS AND FACTORS   ****************************
      YMIN=Y(NPTS+1,1)
      DELTY=Y(NPTS+2,1)
      YLAB(IYAX1)=YMIN
      DO 270 I=1,IYAX
  270 YLAB(IYAX1-I)=YLAB(IYAX1+1-I)+DELTY
      YSCAL=YAXIS/(YLAB(1)-YMIN)
C*********************   INITIALIZE PLOT OUTLINE   ******************************
       NCD=100
      IF(JSTAN.EQ.0) GO TO 2000
      YSTAN=YSCAL*(6.0-YMIN)
 2000 CALL PPLOT(0,0,NCD,NPLOT)
       K=1
      IF(IJOIN.EQ.0) GO TO 500
C***  THE OPTION TO PERMIT JOINING OF POINTS HAS BEEN DELETED
C*********************   PLOT WITHOUT JOINING POINTS   **************************
  500 CONTINUE
      DO 520 L=1,NCV
      JJ=L
      NPOINT=NPT(JJ)
      IF(NPOINT.EQ.0) GO TO 515
      DO 510 N=1,NPOINT
      XT=XSCAL*(X(N,L)-XMIN)
      YT=YSCAL*(Y(N,L)-YMIN)
      IXT=XT+0.5
      IXY=YT+0.5
      IF(NCV.EQ.3) GO TO 517
      CALL PPLOT(IXT,IXY,K,1)
      GO TO 510
  517 L1=L+9
      CALL PPLOT(IXT,IXY,L1,1)
  510 CONTINUE
  515 K=K+1
  520 CONTINUE
C****************************   PLOT OBSERVED DATA   ***************************
550   IF(ISTAN.LT.1) GO TO 565
      DO 560 L=1,3
      DO 570 N=1,NDATA
      XT=XSCAL*(RMDATA(N)-XMIN)
      YT=YSCAL*(OBDATA(L,ISTAN,N)-YMIN)
      IXT=XT+0.5
      IXY=YT+0.5
      L1=L+9
      CALL PPLOT(IXT,IXY,L1,1)
  570 CONTINUE
  560 CONTINUE
565   CONTINUE
C***************************   OUTPUT FINAL PLOT   *****************************
  555 NC=99
      CALL PPLOT(0,0,NC,NPLOT)
      RETURN
      END
```

```
C***********************************************************************
C                                          PPLOT
C***********************************************************************
      SUBROUTINE PPLOT(IX,IY,K,NCT)
      DIMENSION  A(51,101), SYM(14)
      COMMON /CURPLT/ JSTAN, XLAB(11), XAXIS, YAXIS, YLAB(6), YSTAN
      COMMON /AXES/   BOTTOM(12), SIDE(51)
      COMMON /GRID/   KPLOP
      DATA SYM/4H****,4HXXXX,4HOOOO,4HXXXX,4H++++,4H2222,              1
     1 4H    ,4HIIII,4H----,4HHHHH,4HAAAA,4HLLLL,4H&&&&,4H????/
      IXAX1=XAXIS+1.                                                  1270.
      IYAX1=YAXIS+1.                                                  1271.
      JXAX1=XAXIS/10.+1.                                              1272.
      JYAX1=YAXIS/10.+1.                                              1273.
      IF(K-99) 200,220,230                                            1274.
  200 CONTINUE
C*****************   CHECK FOR OFF-SCALE VALUES   **********************
      IF(IY.GE.IYAX1) GO TO 10
      IF(IY.LT.0) GO TO 20
      A(IYAX1-IY,IX+1) = SYM(K)
      RETURN
   10 CONTINUE
      A(1,IX+1) = SYM(13)
      RETURN
   20 CONTINUE
      A(IYAX1,IX+1) = SYM(14)
      RETURN
  220 CONTINUE                                                        1277.
      I=0                                                             1278.
      DO 225 II=1,JYAX1                                               1281.
      I=I+1                                                           1282.
      WRITE(22,310) SIDE(I),YLAB(II),(A(I,J),J=1,IXAX1)               1283.
  310 FORMAT(1H ,A1,F7.1,101A1)                                       1284.
      IF(II.EQ.JYAX1) GO TO 228                                       1285.
      DO 224 JJ=1,9                                                   1286.
      I=I+1                                                           1287.
      IF(I.GT.50) GO TO 500                                           1288.
  223 WRITE(22,320) SIDE(I),(A(I,J),J=1,IXAX1)                        1289.
  320 FORMAT(1H ,A1,7X,101A1)                                         1290.
      GO TO 224                                                       1291.
  500 WRITE(22,510) (A(I,J),J=1,IXAX1)                                1292.
  510 FORMAT(1H ,8X,101A1)                                            1293.
  224 CONTINUE                                                        1294.
  225 CONTINUE                                                        1295.
  226 CONTINUE                                                        1296.
      WRITE(22,102) (XLAB(I),I=1,JXAX1)                               1297.
      WRITE(22,330) BOTTOM                                            1298.
  330 FORMAT(/1H ,20X,12A4)
  102 FORMAT(1H ,11F10.1)                                             1300.
      RETURN                                                          1301.
  230 IYAX=YAXIS                                                      1302.
      DO 250 I=1,IYAX                                                 1303.
      DO 240 J=1,IXAX1                                                1304.
  240 A(I,J)=SYM(7)                                                   1305.
  250 CONTINUE                                                        1307.
```

```
      DO 260 J=1,IXAX1
  260 A(IYAX1,J)=SYM(9)
      DO 270 I=1,IXAX1,10
  270 A(IYAX1,I)=SYM(8)
      IYJ=IYAX1-10
      DO 290 I=11,IYJ,10
      A(I,1)=SYM(9)
  290 CONTINUE
      IF (JSTAN.EQ.0) GO TO 1000
      IY=YSTAN
      DO 1000 J=2,IXAX1
      A(IYAX1-IY,J)=SYM(9)
 1000 CONTINUE
      IF (KPLOP.EQ.0) RETURN
C*********************   FILL IN BACKGROUND GRID ON PLOTS   ***********
      GO TO (1,2,3), KPLOP
C***************   BACKGROUND OPTION 1 - LOW DENSITY   ****************
    1 DO 2700  I=11,IXAX1,10
      DO 2800  J=1,IYAX,5
      A(J,I) = SYM(5)
 2800 CONTINUE
 2700 CONTINUE
      RETURN
C***************   BACKGROUND OPTION 2 - MEDIUM DENSITY   *************
C*************   VERTICAL     *************
    2 DO 2300  I=21,IXAX1,20
      DO 2400  J=1,IYAX
      A(J,I) = SYM(5)
 2400 CONTINUE
 2300 CONTINUE
C*************   HORIZONTAL   *************
      IYJ = IYAX1 - 5
      DO 2500  J=1,IYJ,10
      DO 2600  I=3,IXAX1,2
      A(J,I) = SYM(5)
 2600 CONTINUE   -
 2500 CONTINUE
      RETURN
C****************   BACKGROUND OPTION 3 - HIGH DENSITY   **************
C*************   VERTICAL   ***************
    3 DO 2000  I=11,IXAX1,10
      DO 1900  J=1,IYAX
      A(J,I) = SYM(5)
 1900 CONTINUE
 2000 CONTINUE
C*************   HORIZONTAL   *************
      IYJ = IYAX1 - 5
      DO 2200  J=1,IYJ,5
      DO 2100  I=3,IXAX1,2
      A(J,I) = SYM(5)
 2100 CONTINUE
 2200 CONTINUE
      RETURN
      END
```

```
C***********************************************************************
C                                SCALE
C***********************************************************************
      SUBROUTINE SCALE(ARRAY,AMAX,AMIN,AXLEN,NPTS,INC)
      DIMENSION  ARRAY(103,4), INT(5)
      DATA INT/2,4,5,8,10/
      INCT=IABS(INC)
      IF(AMAX-AMIN) 275,255,275
C**************   RESET MAX AND MIN FOR ZERO RANGE   ********************
  255 IF(AMIN) 265,400,260
  260 AMIN=0.0
      AMAX=2.0*AMAX
      GO TO 275
  265 AMAX=0.0
      AMIN=2.0*AMIN
  275 CONTINUE
C*************************   COMPUTE UNITS/INCH   **********************
      RATE=(AMAX-AMIN)/AXLEN
C*************   SCALE INTERVAL TO LESS THAN 10   ***********************
      A=ALOG10(RATE)
      N=A
      IF(A.LT.0) N=A-0.9999
      RATE=RATE/(10.**N)
      L=RATE+1.00
C*******************   FIND NEXT HIGHER INTERVAL   **********************
  280 DO 300 I=1,5
      IF(L-INT(I)) 320,320,300
  300 CONTINUE
C*****   L IS NEXT HIGHER INTERVAL - RANGE IS SCALED BACK TO FULL SET   ******
  320 L=INT(I)
      RANGE=FLOAT(L)*10.**N
      IF(INC.LT.0) GO TO 350
C**********************   SET UP POSITIVE STEPS   ***********************
      K=AMIN/RANGE
      IF(AMIN.LT.0.) K=K-1
C*******************   CHECK FOR MAL VALUE IN RANGE   *******************
      IF(AMAX.GT.(K+AXLEN)*RANGE) GO TO 330
      I=NPTS*INCT+1
      ARRAY(I,1)=K*RANGE
      I=I+INCT
      ARRAY(I,1)=RANGE
      RETURN
C********************   IF OUTSIDE RANGE RESET L AND N   ****************
  330 L=L+1
      IF(L.LT.11) GO TO 280
      L=2
      N=N+1
  340 GO TO 280
C********************   SET UP NEGATIVE STEPS   *************************
  350 K=AMAX/RANGE
      IF(AMAX.GT.0) K=K+1
      IF(AMIN.LT.(K+AXLEN)*RANGE) GO TO 330
      I=INCT*NPTS+1
      ARRAY(I,1)=K*RANGE
      I=I+INCT
      ARRAY(I,1)=-RANGE
      RETURN
  400 WRITE(22,100)
  100 FORMAT(//1H ,10X,'RANGE AND SCALE ARE ZERO ON PLOT ATTEMPT')
      END
```

BIBLIOGRAPHY

1. Water Resources Engineers, Inc., "A Water Quality Model of the Sacramento - San Joaquin Delta," Report to the U.S. Public Health Service, Region IX, June 1965.

2. Water Resources Engineers, Inc., "A Hydraulic Water Quality Model of Suisun and San Pablo Bays," Report to the FWPCA, Southeast Region, March 1966.

3. Federal Water Pollution Control Administration, "San Joaquin Master Drain - Effects on Water Quality of San Francisco Bay and Delta," January 1967.

4. Feigner, K. and H.S. Harris, "Documentation Report - FWQA Dynamic Estuary Model," U.S. Department of Interior, FWQA, July 1970.

5. Clark, L.J. and K.D. Feigner, "Mathematical Model Studies of Water Quality in the Potomac Estuary," Technical Report No. 33, Annapolis Field Office, EPA Region III, March 1972.

6. Jaworski, N.A., L.J. Clark, and K.D. Feigner, "A Water Resource - Water Supply Study of the Potomac Estuary," Technical Report No. 35, Annapolis Field Office, EPA Region III, April 1971.

7. Clark, L.J. and N.A. Jaworski, "Nutrient Transport and Dissolved Oxygen Budget Studies in the Potomac Estuary," Technical Report No. 37, Annapolis Field Office, EPA Region III, October 1972.

8. Clark, L.J., D.K. Donnelly, and O. Villa, Jr., "Summary Conclusions from the forthcoming Technical Report No. 56, Nutrient Enrichment and Control Requirements in the Upper Chesapeake Bay," Annapolis Field Office, EPA Region III, August 1973.

9. Clark, L.J., R.B. Ambrose, Jr., and R.C. Crain, "A Water Quality Modeling Study of the Delaware Estuary," Technical Report No. 62, Annapolis Field Office, EPA Region III, January 1978.

10. Chow, V.T., "Open Channel Hydraulics," John Wiley & Sons, New York, New York.

11. Cowan, W.L., "Estimating Hydraulic Roughness Coefficients," *Agricultural Engineering*, v.37, n.7, July 1956.

12. Boyer, M.C., "Estimating the Manning Coefficient from an Average Bed Roughness in Open Channels," *Transactions, AGU*, v.35, n.6, December 1954.

13. Langbein, W.E., "Determination of Manning's n from Vertical-Velocity Curves," *Transactions, AGU*, part II, July 1940.

14. Einstein, H.A. and H.L. Barbarossa, "River Channel Roughness," *Transactions, ASCE*, v.117, 1952.

15. Davidson, B., R. Vichnevetsky, and H.T. Wang, "Numerical Techniques for Estimating Best - Distributed Manning Roughness Coefficients for Open Estuarial River Systems," *Water Resour. Res.*, v.15, n.5, October 1978.